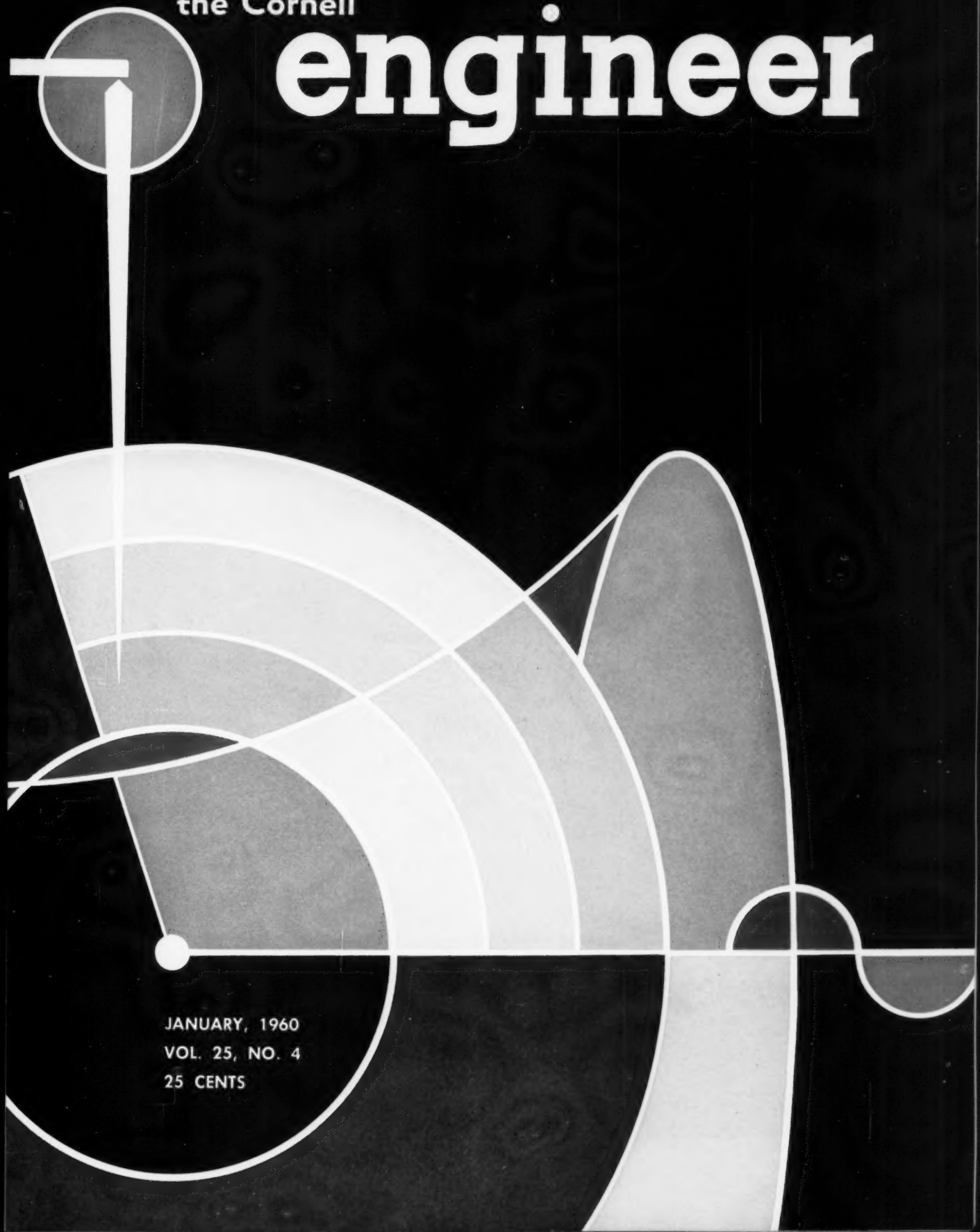
the Cornell engineer



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VOL. 25, NO. 4
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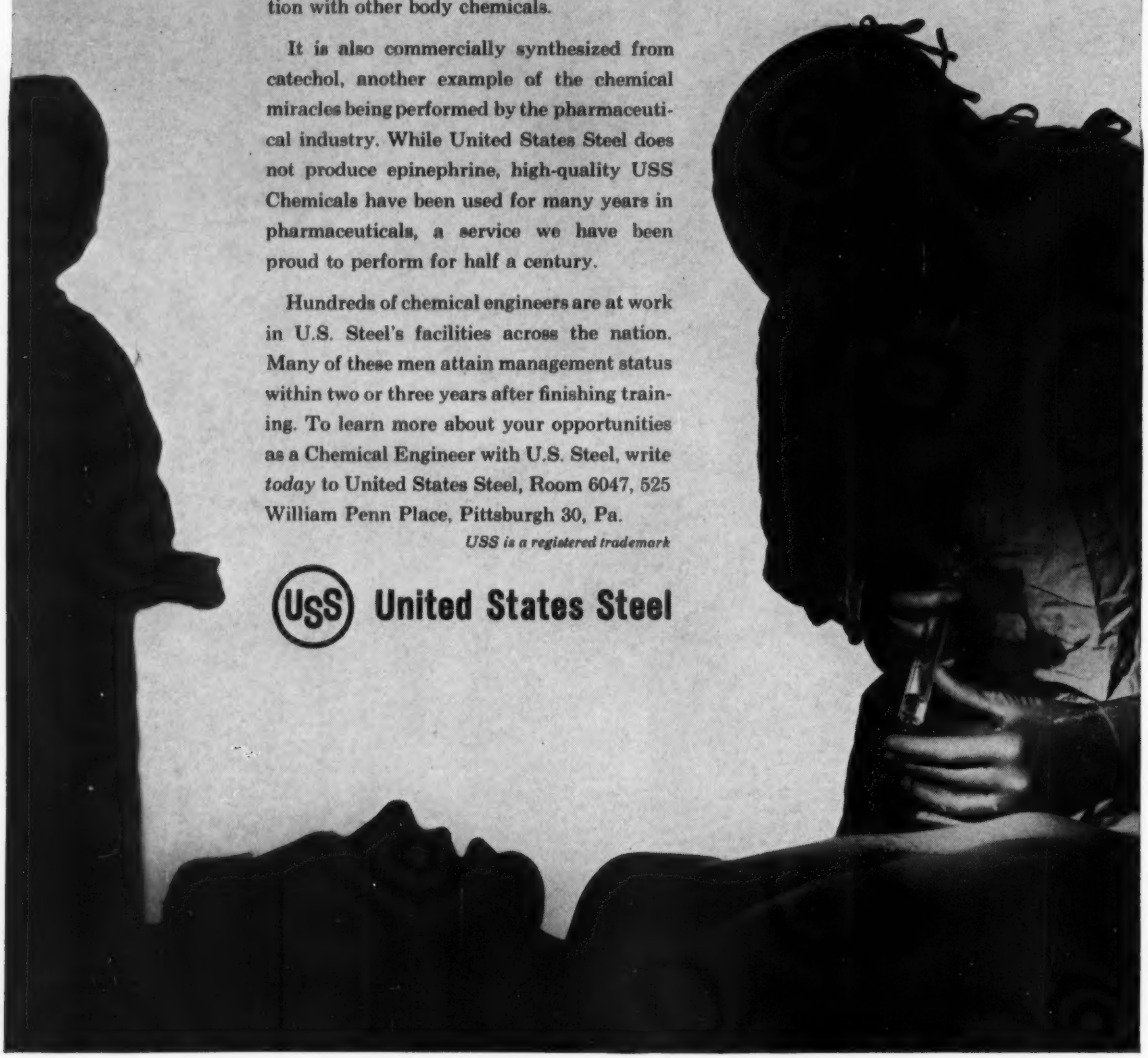

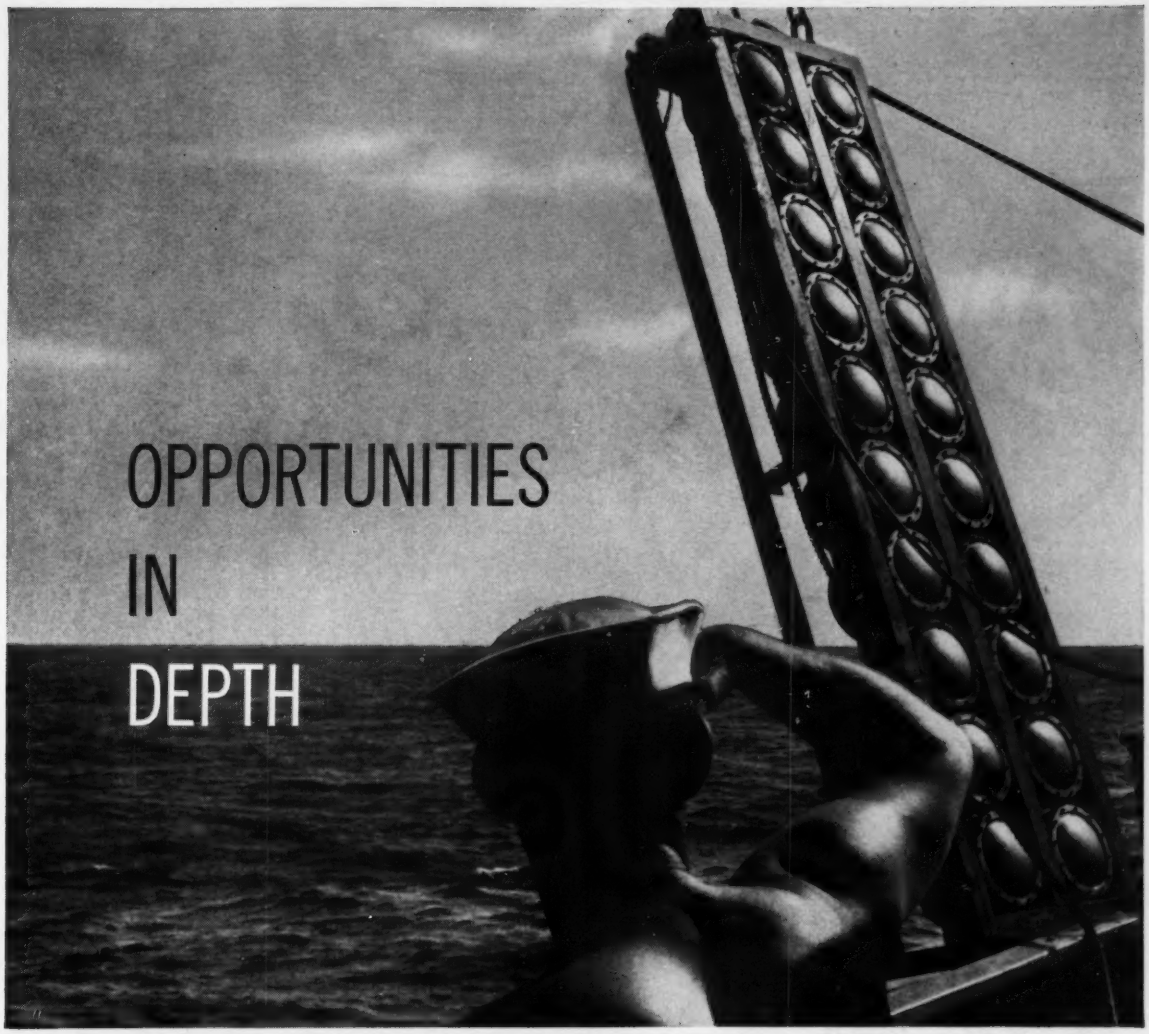

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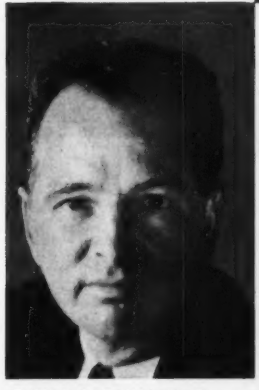

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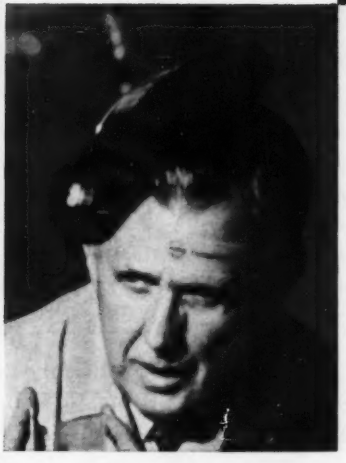

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Photo Science

Professor Simpson Linke

Professor Simpson Linke of the School of Electrical Engineering will be the new faculty advisor to the CORNELL ENGINEER. He will fill the post left vacant by the resignation of Professor Edwin B. Watson.

Professor Linke is active in campus affairs. He is a member of the University Calendar Committee and the College of Engineering Nuclear Curriculum Committee. He is chairman of the Senior Project Committee of the School of Electrical Engineering and has also been faculty advisor to Eta Kappa Nu, electrical engineering honorary.

Professor Linke received the B.S. in E.E. degree from the University of Tennessee in 1941 and the M.E.E. degree from Cornell in 1949. He began teaching at the University in 1946 as a graduate instructor and is now an associate professor. He served four years as a radar officer in the Signal Corps. During his last sabbatical, he was senior electrical engineer for the Philadelphia Electric Company. His main fields of interest are those of power systems analysis, d-c transmission, advanced methods of power generation and the behavior of electric arcs in vacuum.

Professor Linke is vice chairman of the Ithaca chapter of the American Institute of Electrical Engineers and a member of the American Association of University Professors, Eta Kappa Nu, and Sigma Xi.

the Cornell **engineer**

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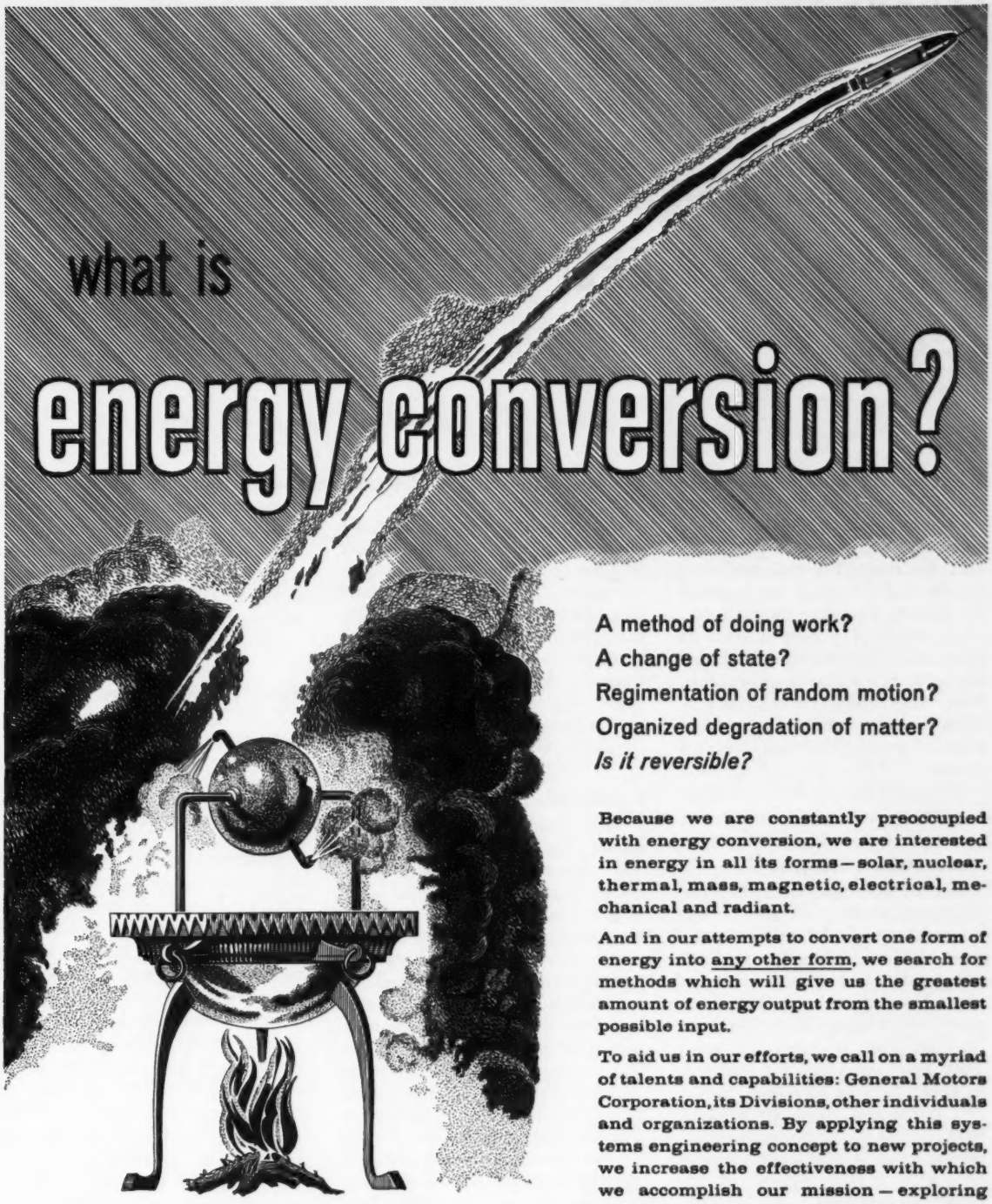

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Editorial . . .

HUMANITIES REQUIREMENTS NEED REVISION

Engineering educators have recently shown a justifiable concern for the humanities courses in their curricula. The pages of past CORNELL ENGINEERS are crammed with articles and editorials emphasizing the need to liberalize the engineer. As a result of pressures such as these, each engineering school now has some humanities requirements. Every engineering curriculum provides an opportunity for a minimum of twenty-four non-technical courses excluding the college-wide requirement of two terms of basic English.

Type of Liberal Education

But an examination of students' programs reveals that total credit hours have no relationship to the type of liberal education students are getting. If humanities courses are to have any meaning, they must provide two things. First they must broaden the student's horizons. They must introduce the engineer to fields such as literature, music, art, philosophy, and government with which he is probably unfamiliar. Secondly they must acquaint him with a new method of approaching problems.

A student taking a liberal arts program gains, after four years, a facility with certain reasoning processes. The engineer, familiar with a technical approach to problem solving, cannot hope to acquire the same kind of knowledge after only twenty-four credit hours of study, but he must be made to realize that the humanities area exists and encouraged to investigate it further after graduation.

Unfortunately many of Cornell's engineering schools do not appear to give these objectives any consideration. Instead they dump three-quarters of a student's non-technical hours into his fifth year, place strait-jacket requirements on those he may take in his earlier years, and cannot understand why the engineer does not take an enthusiastic interest in his work.

Attitude Has Unfortunate Effects

The results of this attitude among the schools are appalling. The required courses become watered down with special engineering sections. When the engineer reaches his fifth year, he finds that he does not have the required prerequisites to take any advanced humanities study and must spend his time in elementary courses, where he is usually placed in sections with first and second-year students. With no real intellectual stimuli available to him in the humanities, the engineer searches for the most trivial courses; looking for average-raisers to satisfy any basic requirements his school may have established. The knowledge he gains can probably be condensed into a moderate-size book, "Handy Facts for High School Graduates."

The student is not entirely blameless for this situation. Certain departments of the College of Arts and Sciences do open their more advanced courses to interested engineers without prerequisites. But students must be willing to seek these courses out and do the work required. Some engineers, unfortunately, must be forced into more significant humanities courses; consequently, the Engineering College must provide the required impetus.

Means For Improvement

First, some minimum college-wide standard must be established. But more important, the courses must be evenly distributed throughout the five-year program. Assuming that the two-term English requirement in the freshman year will be continued, we believe that each student should be required to take an additional two-term sequence of basic courses in his sophomore year and another in a different department in his junior year. In the fourth and fifth years, he should be obliged to take a minimun of nine additional hours of *advanced* work in one of these departments. Any compulsory speech or history courses can be included in the fifth year where they will not limit the student's opportunity to take prerequisites in departments of his choosing.

With a college-wide program of this nature, backed by conscientious faculty-advisors and cooperative professors in the College of Arts and Sciences, the humanities training given to engineers can begin to have some significance.

A.S.R.

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THE CORNELL

engineer

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COVER is an abstract design of common phonographic equipment including: arm, stylus, cartridge, speaker, and record. Designed by Leonidas Ioannou, CE '63, it was inspired by the article appearing on page 24.

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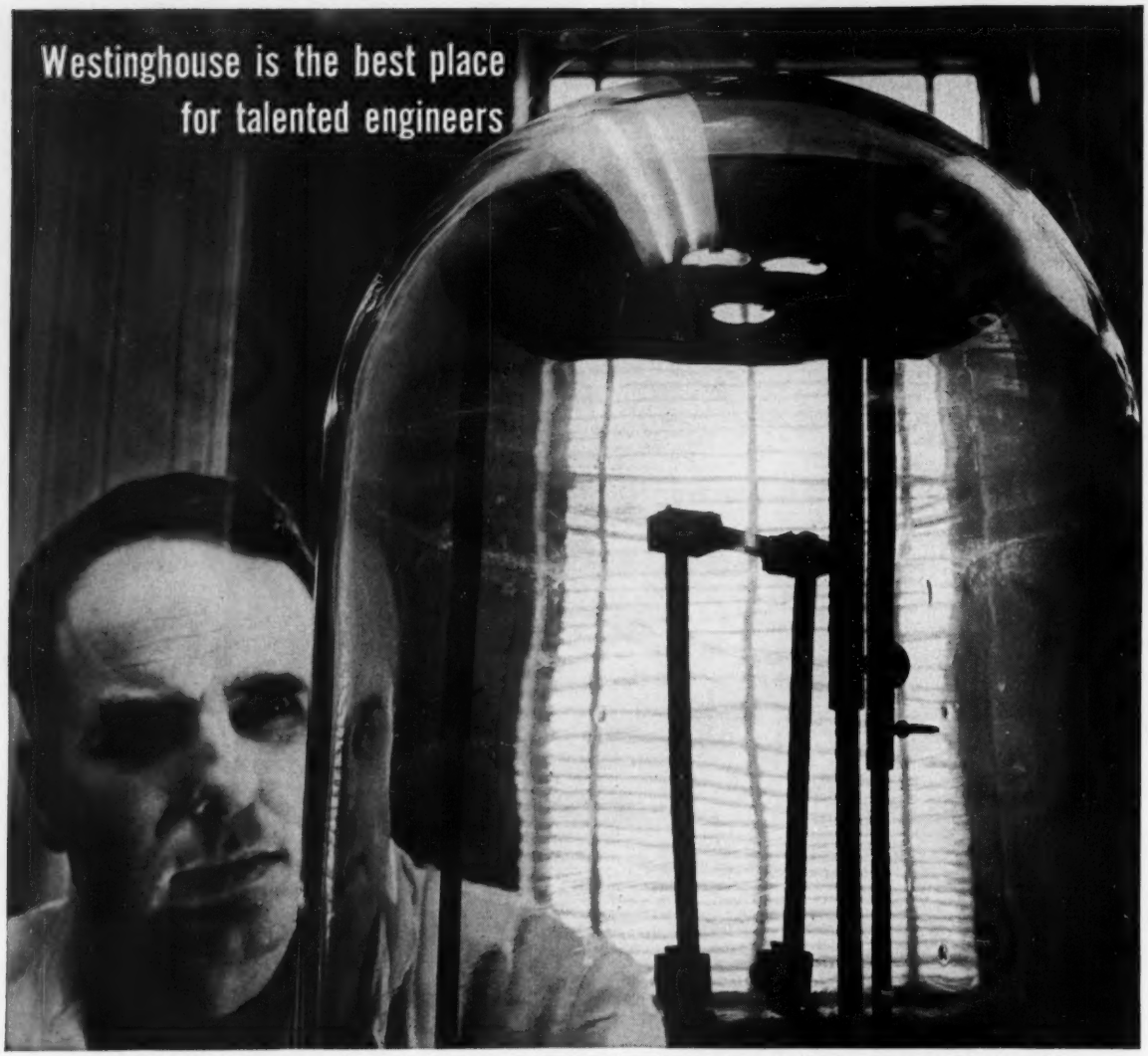

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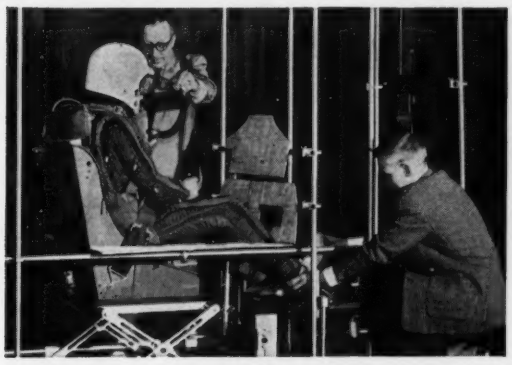

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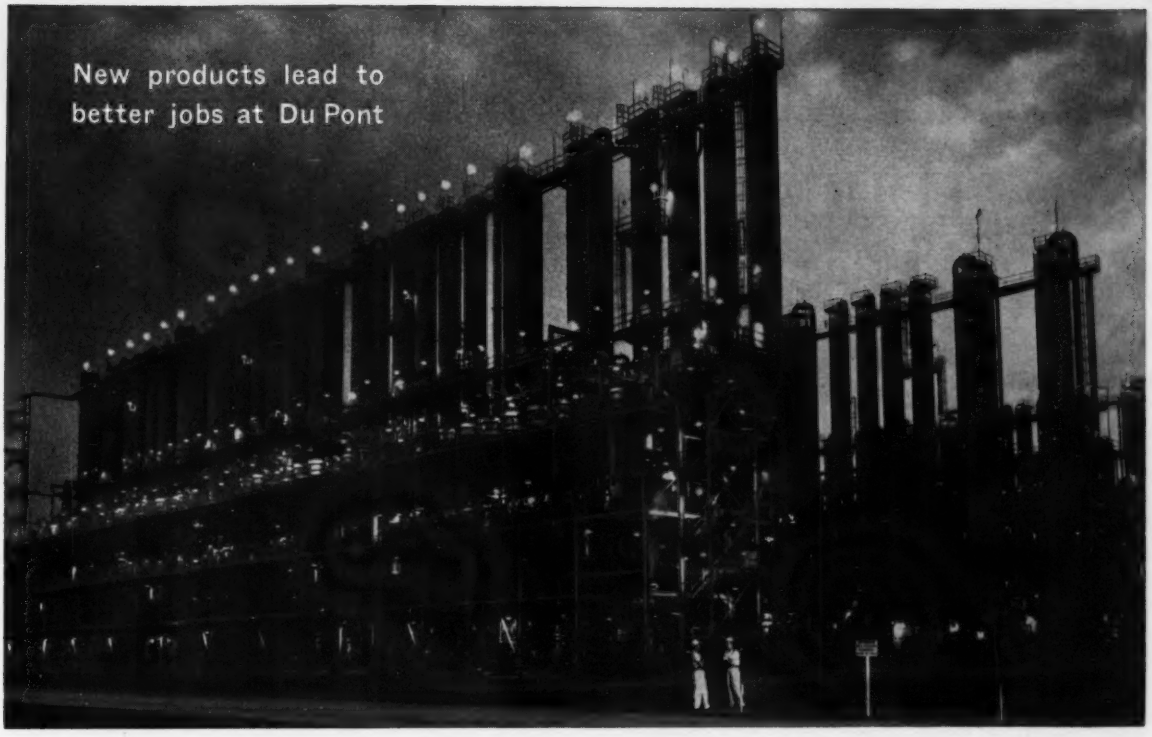

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THREE VIEWS OF ENGINEERING EDUCATION AT CORNELL

On October 16 and 17, 1959, the ninth meeting of the Cornell University Council was held in James Law Auditorium of the Veterinary College. The Council, which consists mainly of alumni and Faculty, was formed to aid Cornell in the areas of alumni relations and fund-raising, and "to make recommendations and carry out missions entrusted to it for the advancement of the usefulness and service of the University."

Printed here are three speeches of special interest presented at the meeting. Dale R. Corson, Dean of the College of Engineering, outlines the rapid changes in science and technology that are requiring new approaches to engineering education. Henry G. Booker, Director of the School of Electrical Engineering, presents the problems facing graduate education in engineering. James M. Edgar, B.Ch.E. '58, past president of Tau Beta Pi, and now enrolled in the Graduate School of Business and Public Administration, relates his experiences as a student in engineering.

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Dean D. R. Corson

I am new to the job of being dean of the Engineering College and talking to you here about the problems of the College puts me in the position of a student who is required to take a final examination on the first day of the term. However, I will tell you some of the thoughts that are on my mind and outline some of the problems in engineering education as I see them.

To put my later comments in a little better focus, let me point out that engineering is the only profession without pre-professional training. If a person wants to be a doctor or a lawyer or a minister, he takes three or four years of basic work, before he starts his professional training, in which he lays the foundation for his future profession. He studies the arts and the sciences so that he will have a broad base on which to build his professional training and, perhaps most important of all, he has the time to define his professional objectives. He has the time and the opportunity to see exactly what he wishes to do in life. Engineering is different. A student starts his professional training at age 18 when he enters college as a freshman. Not only must he have his professional objectives in mind at that age, but he must build the liberal-studies base as he goes alone. Now I do not consider this latter requirement especially bad, since any person's college training in liberal subjects can at best provide him with a start toward an education. Most of his understanding and most of his insight are going to come from his reading and from his study after he leaves college. Since we have a five-year engineering program at Cornell, and since we live in close association with the liberal disciplines, the engineering student here has an excellent opportunity to see the humanities and the social sciences in broad perspective and to develop his interest in non-technical fields. As with everyone else, he is going to gain most of his education in these areas after he leaves the University. Mr. Edgar will discuss some aspects of this problem later on.

Let me come now to some of the specific problems of engineering education. First of all, what about the students? The number of young people going into engineering in the last few years has been decreasing. In the fall of 1958, freshman engineering enrollments were down 11% on the average all over the country and we were also down about the same amount, from 635 to 547. This year the number of applications were down again, but the fraction who accepted our offer of admission was up considerably so that our freshman class has 535 this year, only a handful fewer than last year. By every way we have to judge ability, the quality is higher than normal this year. I think these trends in enrollment are, to a considerable degree, the result of the Sputnik fever which hit us two years ago. There has been a great deal of talk about science in these two years and many students who would have gone into engineering ordinarily, have gone into science instead. I think that much of this talk has been misplaced. The satellite and rocket achievements have been engineering achievements not science achievements, although some of the measurements which have been made with the satellites have scientific interest. The country needs more engineers and there is no doubt that our enrollment will increase. We now have 1850 undergraduates and we consider 2400 the optimum number. I am confident we will get there in a few years.

Now, what about the staff? We already have a high quality staff but as people retire and as the student body grows, we must add new staff members and this is one of our biggest problems. Competition is severe and we repeatedly fail to get the promising young people we go after. Salary is the biggest factor here. Our average undergraduate going into industry started at more than $6000 last year and it is not uncommon for a Ph.D. graduate to start at $12,000. You can see where this leaves us when we offer the same young Ph.D. $5000 to $7000. Furthermore, many of the big companies operate engineering and science laboratories with academic atmospheres so that the young graduate not only finds high salaries in industry, but he finds the ivy on the walls as well. This competition for staff also extends to older engineers and scientists. Our professors are continually bombarded with offers from industry. Some of the west coast aircraft and missiles companies have staffed their research and development laboratories to a considerable extent with former university professors. Only last summer we lost one of our best teachers to industry.

The competition is so keen that even universities are now paying premium salaries to get key people. To put the matter graphically, perhaps 100 different universities may each be seeking a single key professor, at a premium salary, from one of a group of, say, 10 major universities. Thus each of the ten universities is under fire ten times over. Then the ten start sniping at each other. I know one Cornell department which last year countered $30,000 worth of salary increase offers from other universities with $4,000 worth of raises here. These offers came from such places as MIT, Chicago and California. We can no longer include the view from the Library Slope in a man's salary and tell him it is worth $1,000 a year. The Universities which are going to remain strong are those which simply will not be outbid. Do not think that we can relax now that we have a beautiful new engineering quadrangle. We still have serious problems.

Finally, what about the curriculum? As I look at the field of engineering, there is one overwhelming factor which dominates my view. This factor is the accelerating pace of technological development. We are in a period when the time lag between discovery and application is shrinking rapidly. We can see what is happening when we look backwards in time. The laws of electromagnetic induction, for example, first discovered about 130 years ago, were not applied to engineering problems for some fifty years. In the case of radio communication, the time lag was somewhat shorter. In the case of uranium fission and nuclear energy the time lag was only about six years, and in some of the current developments the time lag is almost zero. We must train students today so

that ten or five years or even one year from now they can work in fields that have not yet been invented. Our problem is how to provide this training.

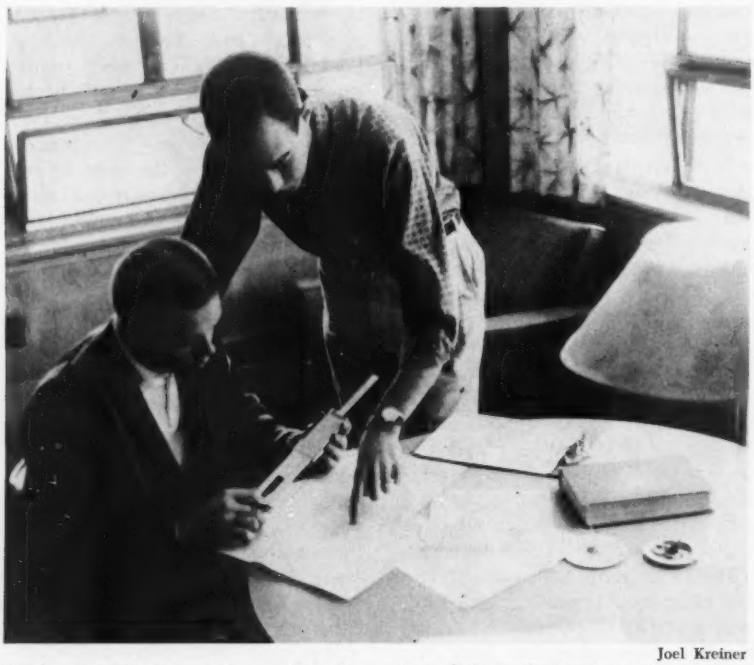
In trying to solve this problem we are faced with a dilemma, for it appears that we must offer two different curricula. We know that we must emphasize engineering science. An electrical engineer, for example, cannot build a supersensitive receiver for radio waves using the latest developments in solid-state physics unless he understands the physics involved. On the other hand the country needs engineers who are going into manufacturing operations, or into management, or into highway construction, or who are going into hundreds of other equally important areas which do not require so much scientific training.

How shall we meet both these demands? There are two ways and we are doing both of them. One way is to meet the engineering science needs through special curricula as we are doing in our engineering physics department. Our five-year program makes it possible for us to offer an engineering physics curriculum which is firmly built on basic engineering disciplines but which, at the same time, is highly oriented toward mathematics and the sciences and which includes a good program of liberal studies. The second way of coping with the problem is to offer alternative paths within a given curriculum. We are doing this to some extent in electrical engineering. Beginning in the third year a student can follow a normal, old-fashioned, 1958 electrical engineering course or he can go rather heavily in a mathematics-physics direction if he is so inclined. I believe that this dual-path approach to the problem is going to occupy more and more of our effort in the future.

Erik Gregerson

Laboratory courses occupy a great deal of the upperclass engineer's time. Experiments such as this one in the materials department provide grounding in some of the fundamental principles.

Let's turn to another curriculum problem—the question of whole new fields of technical interest. One such field is that of engineering materials. Everywhere we turn we see progress limited by the materials available. For example, nuclear power engineers would like to design nuclear reactors to operate at very high temperatures, 2000° or 3000°, or even higher, but the available materials are inadequate. The missile designer must have lighter, stronger, and more heat-resistant materials for his rockets and for his nose cones. The electronics engineer must find new materials out of which to make transistors which will operate at higher temperatures and in higher radiation fields, and which lend themselves to simple manufacturing techniques. In this country we have a number of billion dollar development programs which depend on new materials for their success. We must train engineers in the materials field, and we must do research in the field. I am convinced that the next decade will see great emphasis on this problem. At Cornell we already have a good start.



Joel Kreiner

Freshmen engineers waste no time in starting their professional training. James Ferguson and Richard Abrams, ChemE '64, wrestle with a problem in physics 121, one of the engineers' most important basic courses.

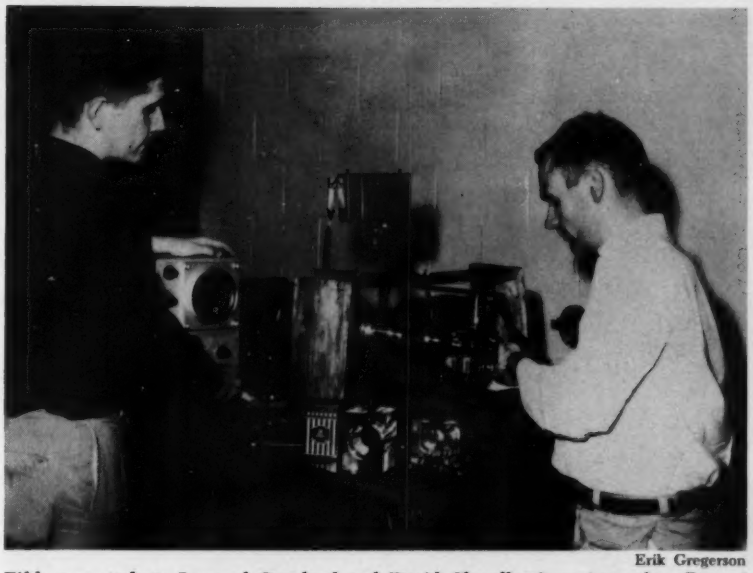
We have a metallurgical engineering department, we have a department of engineering mechanics and materials, and we have a good materials program in our engineering physics department. Through the generosity of Mr. F. N. Bard we are going to have a new metallurgy building. The whole materials picture is bright.

A second new and important engineering field is that of nuclear power. When we examine this country's power requirement for the next fifty years, the prospect is frightening. Coal and oil cannot meet the needs and we must have other sources of energy. Fission reactors represent the principal hope at present, and nuclear power stations are springing up all around the country. Nuclear power for propulsion purposes is already being exploited. Several nuclear submarines are in operation and the first nuclear merchant ship, the SS Savannah, was launched some months ago. The development of nuclear propelled aircraft is absorbing large sums of money and the development of nuclear propelled rockets requires only time—and money. These developments make a big demand for engineers trained in the nuclear field. For several years we have had a nuclear power option which students in any of our engineering disciplines may elect in the last two years of undergraduate work. Now, beginning in the next few months, we are going to build a nuclear reactor of modest power but of unique design which will adapt itself well to our teaching and research requirements. While I am on the subject of power I should mention the growing interest in still other methods of power generation—thermo-nuclear fusion, for example, and in new methods of power conversion: that is conversion from heat to electrical power. Research in these new power areas is developing rapidly in this country and we are discussing what our role at Cornell should be.

There are other new fields, such as space research, which have their impact on us but time does not permit further discussion.

From my examples of the new problems which face engineers, it is easy to believe that graduate study in engineering is of growing importance. Many of today's engineering problems are so complicated that a person with only undergraduate training cannot possibly cope with them. I know one corporation which requires all its engineers to have at least a master's degree. If an employee does not have the degree he must go to school, on company time, to get it.

I have talked about a few of the problems which I see and told you about a few of the steps already under way to meet these problems. I am new to the job and my ideas are necessarily immature, but I have succeeded in my purpose if I have left you with the impression that we are alert to the new demands on engineering education, that we find the prospects for the future exciting, and that we intend to continue the Cornell tradition of excellence in engineering education. Thank you.



Erik Gregerson

Fifth year students Leonard Copeland and David Chandler investigate the effect of large clearance in plain journal bearings.

Prof. H. G. Booker

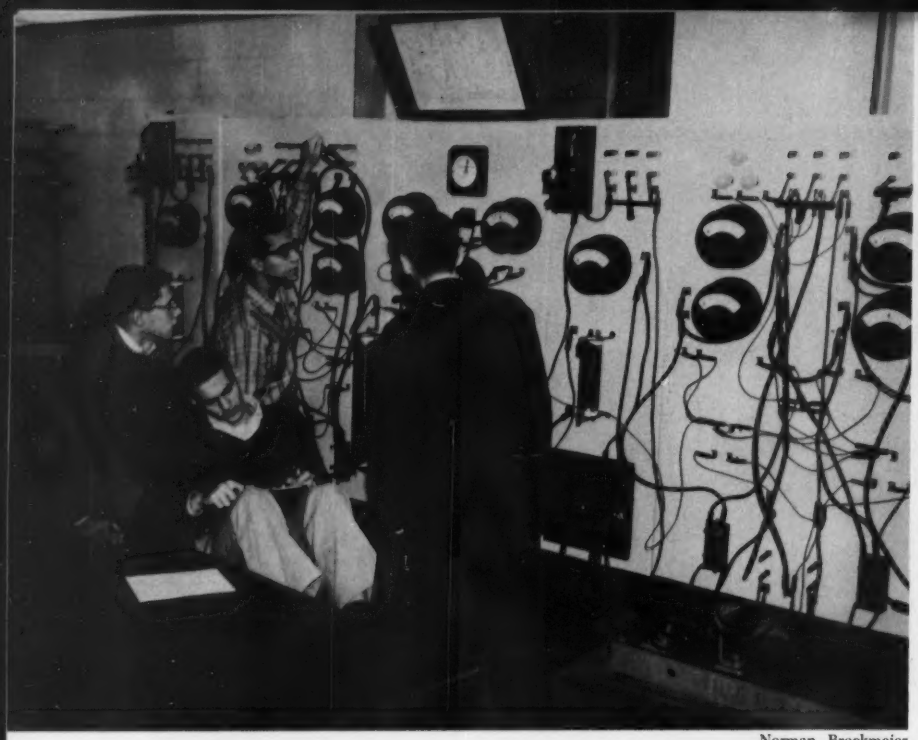
I am to speak about Graduate Education in the Engineering College of this University and about what is preventing us at the present time from doing the whole job that needs to be done. To do this I would like to begin by asking, and answering, a few deceptively simple questions about education in general.

Firstly, what is the objective of a University such as Cornell? My one sentence answer is this: To take in good brains from high school and make these brains function as well as possible.

Secondly, what is the objective of the Engineering College? It is to exploit the potentialities of engineering for the purpose of making students' brains function as well as possible. Notice that engineering is the *means*, not the objective. Development of student brains is the objective; study of engineering is the means to that objective in the Engineering College.

The third question is: what is the objective of undergraduate education? It is to exploit what is *well known* in order to make students' brains work as well as possible. In the Engineering College it is the objective of undergraduate education to exploit what is well known in *engineering* for the purpose of developing students' brains. The *means* for attaining the objectives of undergraduate education are books, lectures, and so forth. In undergraduate education *group* activities are feasible that greatly reduce the cost to the University per student.

It is appropriate to mention at this point the following educational fallacy. It is sometimes stated that, because much more is known today than it was thirty years ago, therefore students have much more to learn today. This is untrue. What *is* true is that there is now more material from which



Norman Brockmeier

Undergraduate studies in the power field help these students to develop their minds. But insufficient funds have limited advanced research in this field.

to *select* in the process of making brains work as well as possible. The students *brains* are not different today from what they were thirty years ago.

The upshot of an undergraduate educational program is, *not* that the student knows everything, but that the student's brain has been made to work as well as is possible by studying what is well known. When he completes his undergraduate education, a student has reasonable confidence that he can understand anything that some one else has already understood.

Now for the conduct of our national life it is not sufficient, in engineering or in any field, merely to understand and apply what is well known. Our best brains are required to attack what has not been done before. With the ever increasing acceleration of technical progress to which Dean Corson has drawn attention, our best brains in engineering are required to attack *unsolved* problems at an ever increasing rate. Nor is the ability to deal with novel situations restricted to the technical field. Many of you know far better than I do the importance in business of coping quickly and decisively with novel situations. And the same is true in national and international politics. Graduate education is the University technique for developing the minds of the best students to attack problems and situations not previously encountered.

Now I am prepared to assert that the Engineering Colleges of our Universities have, in the past, largely failed to meet the challenge of graduate education. And Cornell is no exception. In the past decade, real efforts have been made in a number of areas of the Engineering College to create a graduate educational program to give students the mental development, experience, and confidence to cope with the novel. Even in these areas however the programs do not rest on a sound financial foundation. And there are a number of areas where virtually *nothing* has been done. For example, in the School of Electrical Engineering essentially nothing is being done to produce men capable of exploring and exploiting the exciting new possibilities that now face us in the generation of electric power. Let us see why not.

Remembering that the objective of graduate education is to develop minds capable of dealing with novel situations, let us first ask what are the means available to a University for pursuing this educational objective. The principal technique is to have the graduate students take a major part in a dynamic program of research on the campus. Notice that research is not itself the objective, as in many industrial and government laboratories. Academic research is a means to an educational end. The educational end is a body of highly intelligent people trained to meet novel situations with confidence.

Note that specialization is *not* an objective of graduate education. Specialization is *involved*, but only as a *means*. An individual graduate student cannot advance the whole frontier of knowledge. He must select a narrow sector for his own educational development. Specialization is involved as the graduate student approaches that portion of the frontier of knowledge that he proposes to advance, Thus, while specialization is involved in the *approach*, the objective is broad: to be able to deal confidently with the novel throughout life.

Let us now see how this applies to graduate education in the field of electric power. The problem is to exploit new ideas in the generation of electric power to train graduate students in novel thinking. The procedure is to establish in the School of Electrical Engineering an active program of *research* in new methods of generating electric power. This is not research to replace what is done in industrial or government laboratories. It is research in order to provide the people required to man the industrial and government research laboratories. With no existing Cornell program of research in new methods of generating electric power, how does the School of Electrical Engineering get one started? If once we *got* going, we could *keep* going to a large extent on contract funds from the federal government or from industry. Such funds are not however available to us unless we get into the business on our own initiative. How does *anyone* get started in *any* new business? The answer, as you know better than I do, is by investing capital. Venture capital to establish the kind of research programs required to train our best students to face what is unknown in our future.

James Edgar, Ch.E. '59

There is no doubt in my mind that I would never have come to Cornell if it had not been for some

dedicated Cornell alumni living in my home town. For me to now describe my impressions of undergraduate life as an engineering student to another group of dedicated Cornell alumni gives me particular pleasure.

As I interpret many of the comments that I have recently heard and read, all high school students anticipating a college education are faced with a choice between a vocationally oriented course of study like engineering and a liberal education centered on the humanities. The strong implication is that by attending an engineering college a student acquires a specialized and technical training at the expense of the broadening humanities. In my opinion, any attempt to relate engineering training to a liberal education on an either-or basis is seriously clouding the central issue. It is the individual himself who determines the education that he will receive. It is only when the individual abdicates his fundamental responsibility for choosing and then constantly modifying his educational goals that the curriculum determines the scope of his learning. From my own associations as an undergraduate I am convinced that there is no curriculum that will guarantee a liberal education for anyone unless that person is first inculcated with a desire to learn and explore. Alternatively, there is no curriculum in this university that can prevent a student from acquiring a liberal education if he has a desire for it.

There is another stigma that occasionally becomes attached to the engineering course of study. As I understand it, many people—usually nonengineers—would have us believe that the burdens of the engineering courses are so overpowering that a person attempting to master them can by necessity have little time for any other pursuits, either academic or otherwise. Nothing could be further from the truth. Permit me to cite just a few examples from the area of extra-curricular activities. The president of the Interfraternity Council, in addition to simultaneously serving as president of his own fraternity, is a fourth year mechanical engineer. Perhaps you have heard of our new student government; its vice-president, who is elected at large from the student body, is studying his fourth year of chemical engineering. Another of the key leadership responsibilities on campus involves the selection and training of approximately 250 orientation counsellors; this job was handled admirably this year by another senior in mechanical engineering. I should also add here that the membership of Sphinx Head and Quill and Dagger as well as the membership of Red Key and Aleph Samach contain a substantial number of engineering students. And lest you think that these students have made their activities record at the expense of their academic pursuits, let me point out that the great majority of those who have proven their leadership ability have also been members of Tau Beta Pi, which is the engineering equivalent of Phi Beta Kappa.

When entering engineering as a freshman, a student knows that he is entering the five-year study of a difficult discipline with its own demanding standards. Probably he realizes that he is about to be tested for the first time in a rather young life. He knows that many

Gary Klock

Engineering physics student Landis Markley, Jr. confers with Donald H. Moyer of the Office of Student Personnel. As a result of such conferences, students are better able to plan their activities after graduation.

Norman Brockmeier

Despite the time and effort required by studies, engineers still have time for extra-curricular activities. These members of the CORNELL ENGINEER staff are discussing plans for the next issue of the magazine.

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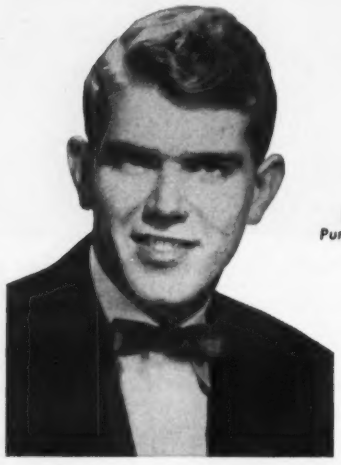

DEANE KEUCH
Purdue University '53

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will come through with flying colors, but that some will fail. For the first time this freshman is entering the adult community to be judged by adult standards. I think that you can begin to understand the exhilaration that this student must feel as he is able to prove to himself that he can master a tough discipline. About this time an amazing transformation can occur. Now I do not for a moment pretend that this transformation occurs only among engineers; quite the contrary. But the fact that it does occur at all may come as a surprise to many. Because the course of study is tough and the student has mastered it, he is not likely to be satisfied with this limited accomplishment. Rather, the self-confidence which is beginning to grow encourages him to look around. About this time self-confidence and the beginning of maturity swirl together, and the narrow concept of college suddenly explodes into an amazingly varied number of possibilities, and individual interests carry their owners in any number of directions. Some become attracted by research and development work in computers, rocket fuels, missile guidance systems, or nuclear power. Others directed more toward an industrial career with possible management responsibility may pursue the studies of economics, finance, accounting, and even law. On still another tack, students will be carried into the realm of music, art, philosophy, literature, and government. Still others will become interested in any number of extra-curricular opportunities for developing and testing their own leadership ability. It is during this period of investigation and trial and error that the interests of a lifetime are uncovered.

As I look back over my five years as an engineering undergraduate and renew the personal associations that appear so clearly in my memory, I am led irretrievably to the fact that an education is determined by the individual and not by the curriculum. In this regard I am reminded of a comment by Francis Bacon that has been often quoted by one of my favorite professors: "Education is what remains when you have forgotten that which you set out to learn."

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F-M BROADCASTING

by Peter Van Raalte EE '60

The growth of f-m broadcasting in the United States has been somewhat erratic. It has been advanced by significant technical developments and at the same time has been retarded by financial difficulties. The result is a melee of confusion about the status of the f-m medium in the mind of the public.

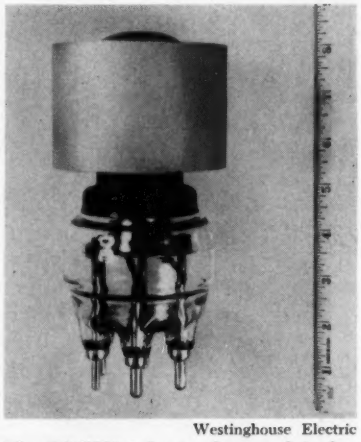
F-M Through 1945

The concept of frequency modulation was first brought to light with the invention of the Poulsen arc, a type of arc used in some radio-telegraph transmitters. It was not possible to send code with the Poulsen arc by interrupting the circuit; instead, frequency-shift keying was employed. It was then proposed that the human voice be used to continuously modulate the frequency of a transmitted wave, but at that time techniques for testing such an idea did not exist. As the complexities of amplitude modulation became better known and understood, frequency modulation was again proposed, this time in the hope of conserving electromagnetic spectrum space. This hope, however, was short-lived; for in 1922, Carson proved mathematically that it was not possible to make a practical frequency modulated system with a smaller effective bandwidth than that of amplitude modulation. Carson remarked further about f-m:

> In the more general case where the signal must be represented by an arbitrary $f(t)$, as is the case in telephonic transmission, a general solution can . . . be gotten . . .
>
> $I = A\cos\omega_o t - \omega_o h A \int f(t)dt \sin\omega_o t$
>
> The second term is a modulated wave, but the amplitude instead of being proportional to the signal wave is proportional to its integral. Consequently this type of modulation inherently distorts without any compensating advantages whatsoever . . .
>
> Superiority, however, has been claimed for the former [frequency modulation] on the alleged ground that, since 'the amplitude is constant,' transient disturbances are minimized. This claim is seen to be quite invalid when the real significance of 'frequency modulation' is analyzed, and no such superiority exists.[1]

In spite of this disturbing conclusion Frank Conrad, the chief engineer of KDKA in Pittsburgh, began to experiment with f-m. He began in 1922 to make tests with a continuous wave transmitter modulated by a condenser microphone that shunted the main tuning condenser of the oscillator. The result of the attempt was a transmission with high noise, distortion, and poor frequency stability.

For some years f-m lay dormant. Major Edwin H. Armstrong, however, did not feel that f-m was a useless idea. Armstrong installed a transmitter in the Empire State Building and used his own modulation technique. In 1933–34 he demonstrated the system to the Radio Corporation of America. He had been able to obtain excellent fidelity and a signal-to-noise ratio far better than that attained in amplitude modulation or in Conrad's tests. Armstrong went as far as multiplexing the system so that, at the same time regular broadcasting was being carried on the main channel, three completely different signals were being carried on three sub-channels.



Westinghouse Electric

The WL5736 tube is often used in five kw f-m installations.

Armstrong succeeded where Conrad failed because Armstrong used wide-band f-m. The maximum swing on Armstrong's transmitter was ±75 kc. The difference in techniques produced a very striking difference in results. Armstrong's reception was almost unaffected by atmospheric disturbances. It showed

a unique signal-capturing ability whereby, if the field strength of the signal were appreciably greater than the field strength of the noise, the receiver would demonstrate an apparent increase in signal-to-noise ratio; thus the noise was nearly eliminated. It is also of interest that Armstrong's experiments were carried out at a center frequency of 54 mc, a frequency at which line-of-sight propagation exists. Under this condition, f-m stations on the same frequency could be placed as close together as 100 miles and still cause negligible interference to each other.

In 1940 the Federal Communications Commission set apart thirty-five channels for commercial f-m and five channels for noncommercial educational f-m. On October 31, 1940 the FCC issued construction permits to fifteen stations. Throughout World War II, more than forty prewar f-m stations continued to serve some 400,000 receivers in the 42-50 mc band.

Post-War F-M

In June of 1945, before the war was over, the FCC dealt a hard blow to the f-m industry; FCC report 83095 ordered a change in the commercial f-m band from 42–50 mc to 88–106 mc. This order made all commercial f-m equipment obsolete. The FCC did, however, allow interim operation on both bands with a 90-day permit.

While the band change was a set-back to f-m broadcasters and listeners, it seemed to act as a spur to rapid technical development in f-m. In December '45, the Seely discriminator was discovered at RCA. In January '46, Philco invented the gated beam tube, the 6BN6. Zenith and General Electric coordinated on the Phasitron modulator tube in February '46, and in October of the same year, General Electric marketed a transmitter using the Phasitron.

In October 1948, Radio Engineering Laboratories, Inc. came up with a still better f-m modulator known as Serrasoid that could attain a signal-to-noise ratio of 80 db. An experimenter's design of a transistorized f-m receiver was publicized in 1958. Unfortunately, the transistors suggested for the receiver cost between fifteen and thirty dollars each at that time.

Socio-Economic Development Since 1946

F-M STATIONS AUTHORIZED IN U.S.

Date	Total Authorized	On the Air
June 30, 1945	56	.....
June 30, 1946	456	55
June 30, 1947	918	238

Broadcasting Yearbook, 1957

Fig. 1: A-m industry in 1945–1947 cornered many channels in order to keep f-m stations off the air. This explains the discrepancy between the number of stations authorized and on the air.

In spite of the channel-cornering schemes of the a-m industry, as shown in Fig. 1, f-m began to experience a boom in 1947 and continued to boom through 1950. (This growth is graphically represented in Figs. 2 and 3.) This boom is best explained in the light of a description of post-war America. The war had succeeded in inflating the value of the dollar; higher wages and greater buying power resulted. The work week had been shortened and people had more free time than they had had before. With money to buy equipment and time to use it, Americans began to enjoy f-m sets. Soon, however, the novelty began to wear off; and, in the beginning of 1951, the acceptability of f-m as a medium seemed doubtful.

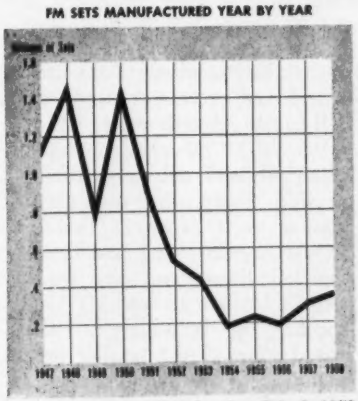
To make matters worse for f-m, television had begun to impress the public. In 1948 the total television time sales had amounted to $8.7 million; by 1951 the figure had grown to nearly $208.6 million for the year.[2] National sponsors and broadcasters began to realize that the big money was in television, so that many talented entertainers were shifted from radio to television. The rapid advancement of television over radio is shown in Figs. 4 and 5.

When one refers to these charts, he should be aware that f-m is only a small part of radio. For, between the years of 1947–1958, the production of f-m sets never exceeded 10 per cent of total set production.[3]

The f-m broadcasting industry found itself badly prepared for the sudden success of television. F-m lacked both a program to encourage advertising agencies to purchase time, as well as a central organization from which this time might be bought. Thus, f-m was caught financially unprepared in 1951.

In 1957 f-m received a bad scare. There was serious talk of again reallocating the f-m broadcast band. In a meeting at Old Point Comfort, Virginia, ex-Commissioner Hennock of the FCC said, "You're not going to be able to hold on to 20 megacycles of spectrum space."[4] Ex-Commissioner Anello said, "It is my personal opinion that the f-m people in this proceeding are in the fight of their lives to retain all of the space that they now have."[5] In the fall of 1958 Radio Engineering Laboratories, Inc. designed and tested a new line of f-m transmitters that could operate in the proposed new f-m band. However, at about this time the FCC issued a statement that they had been "literally flooded" with letters from all over the country expressing con-

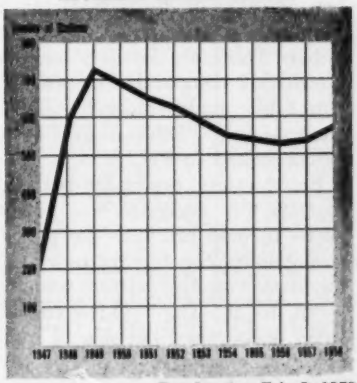
FM SETS MANUFACTURED YEAR BY YEAR



Broadcasting, Feb. 9, 1959

Fig. 2: The sale of f-m receivers are a measure of public acceptance of the medium.

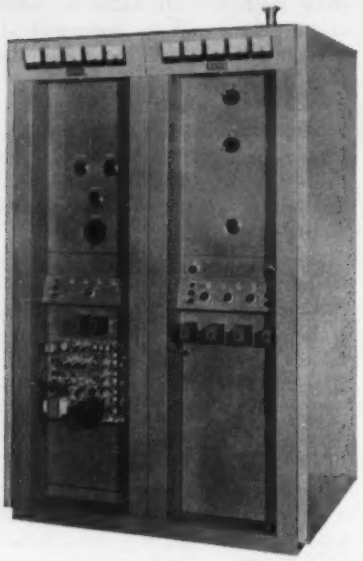
FM STATIONS ON AIR AT YEAR-END



Broadcasting, Feb. 9, 1959

Fig. 3: The success of f-m stations has been rather erratic, but the last three years show a steady rise in stations on the air.

cern over f-m, for another frequency change would probably kill f-m completely.[6] Largely as a result of the public response, the



Gates Radio
This five kw f-m transmitter is used at many medium-power stations.

FCC has taken no definite action on the proposed frequency change. The result of the frequency-change scare was to make the f-m medium even less attractive to advertisers.

The Trend Reverses

While f-m was undergoing its financial decay, the public was being subjected to better and better sound. Movies and records became "stereophonic," "orthophonic," and "full dimensional." With the advent of high fidelity sound, the public developed a new interest in f-m.

The appearance of inexpensive f-m receivers on the market made the medium more accessible to the public. There are f-m sets now on the market comparable in price to a-m table model radios. The increased public interest in f-m is demonstrated in Fig. 6.

Broadcasters gradually realized that the f-m audience was in the upper income bracket. The public was gaining the buying power to buy f-m and the leisure time to listen to it. The "do-it-yourself" trend encouraged the sale of individual high fidelity components, among them, f-m tuners. The mass market that advertising agencies were looking for seemed to be developing, and the future of f-m broadcasting began to look brighter.

F-m's first successful organization was the Rural Radio Network (now the North-East Radio Network). This network originated its programs in Ithaca, N.Y. Each succeeding station received the signal over the air from the previous one and rebroadcasted the program on a different frequency. This network was later incorporated into the QXR Network. These networks furnished buyers with a mode of buying large blocks of f-m time from one organization. The QXR Network has been working on promotion of advertising accounts but has met with only limited success.

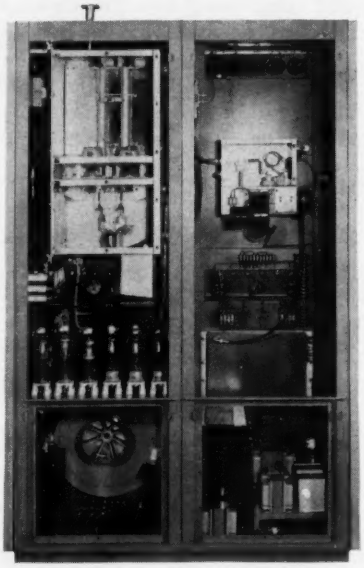
Their future expansion is limited by the maximum possible number of stations in the network. This number is determined by the noise generated by each transmission in the chain; for the noise of each successive transmission is added to the noise of the previous transmission. Thus, the number of transmitters in a chain is determined by the signal-to-noise ratio per transmission divided into the minimum allowable system signal-to-noise ratio.

In 1957, the F-M Development Association was founded. (It was this organization that was largely responsible for the 1957 meeting at Old Point Comfort, Virginia.) The purpose of this group was to actively promote the sale of f-m time through a central booking agency. Any dues-paying member of the group was required to reserve three "spots" each day for the commercials of the Association. The income from the time sold would be evenly divided among the member stations. The Association also intended to finance research and promotion necessary to sell f-m to advertisers.

The F-M Development Association attained only a small membership. Some other organizations similar to it (such as the Good Music Broadcasters) had been organized throughout the country. On September 18 and 19, 1959, a meeting of broadcasters coordinated some of the smaller organizations into one parent group, the National Association of F-M Broadcasters (NAFMB). The magazine *Broadcasting* described the Association as follows:

> NAFMB will function as a successor to the short-lived Assn. of FM Broadcasters formed at last spring's NAB convention following the demise of FM Development Assn. AFMB disbanded last July, authorizing its board to organize a broader and more comprehensive association embracing all industry elements, including conventional and background music fm operations. . . . The complete line-up of NAFMB-member stations may be delivered to a national advertiser on the basis of a persuasive selling presentation. . . .[7]

The f-m broadcasting industry has great hopes that NAFMB will be the effective product of the wedding of less effective organizations.



Gates Radio
The interior of an f-m transmitter must be readily accessible for ease of servicing.

Future

In order to get the views of a professional broadcaster about the future of f-m, the author talked with Mr. Michael R. Hanna, general manager of WHCU, Ithaca, N.Y. Mr. Hanna said it was inevitable that f-m eventually replace a-m. He explained his statement by pointing out the "weather-free" reception of f-m, its signal-capturing property, and the advantages of night-time programming (many a-m stations are required to cease operation at sun-down). He said that f-m would completely replace a-m in all but the least densely

City	Number of channels remaining	Number of applications for available channels	F-m set penetration
Boston	0	–	49.9%
New York	2	5	58.9%
San Francisco	2	3	47.3%
Los Angeles	2	3	40.0%
Philadelphia	2	3	38.0%
Baltimore	2	3	27.9%
Chicago	1	2	41.0%
Washington, D.C.	1	1	41.0%

Brown University

Fig. 6: Penetration is high in major population areas. Set penetration (the per cent of homes equipped with f-m sets) figures were obtained in April 1958.

populated areas of the country such as parts of the West. He further stated that f-m would make "significant inroads" upon a-m broadcasting within five years.

Mr. Hanna told me that a short while ago, when he was in Washington, D.C., he spoke to an FCC commissioner. The commissioner said that the FCC was encouraging f-m broadcasting by granting many a-m licenses, thus causing the a-m industry to crowd itself off the band. This was already too apparent, said Hanna, at the high end of the a-m broadcast band at night.

Many f-m stations hope to use multiplex operation to augment their incomes. Multiplex operation is often recommended in connection with stereophonic broadcasts. Although stereophonic broadcasts are being made (for instance, by WBAI in New York City), and although receiver-converters are manufactured by some companies (for instance, Madison-Fielding and Fischer), the market for these broadcasts has remained small.

I believe that transistorized f-m receivers are in the offing. Their main deterrent until now has been the high cost of high-frequency transistors. Recently, however, Philco marketed a transistorized television set. If these or similar sets prove popular, the cost of high-frequency transistors will probably come down, and transistorized f-m receivers will become practical.

While the fidelity of f-m broadcasting is undeniable, I disagree with Mr. Hanna that f-m will replace a-m. Rather, I believe that f-m broadcasting will find an equilibrium with the other mass media, just as newspapers, movies, a-m broadcasting, and television each attained some kind of stable equilibrium with its predecessor. I have strong faith that the NAFMB will succeed in promoting the medium to advertisers and that, within ten years, f-m will have a coverage and an income comparable to a-m.

FOOTNOTES

[1] Carson, "Notes on the Theory of Modulation," *Proceedings of the IRE*, vol 10, 1922, p. 57.
[2] "Television Time Sales 1948–1957," *Broadcasting Yearbook* 1957, p. B-135.
[3] Contrast the figures in *Broadcasting Yearbook*, 1958, p. B-134 with Fig. 2.
[4] Lyman Allen, "What Makes FM Succeed" North Lincoln, Massachusetts, p. 36.
[5] *Ibid.*, p. 36.
[6] *Ibid.*, p. 37.
[7] "FM Sounds Battle Cry," *Broadcasting*, September 28, 1959, p. 104.

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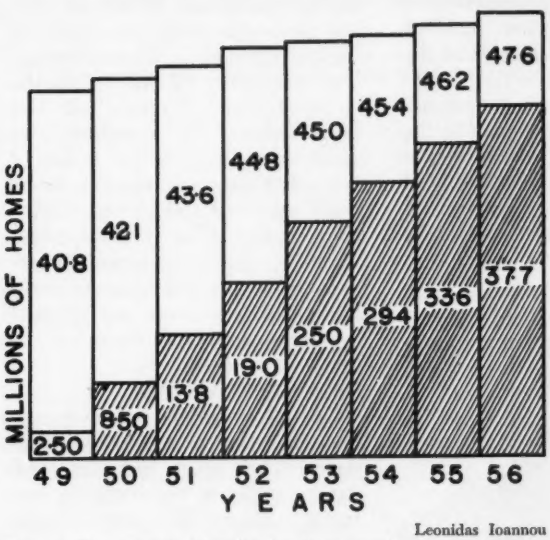
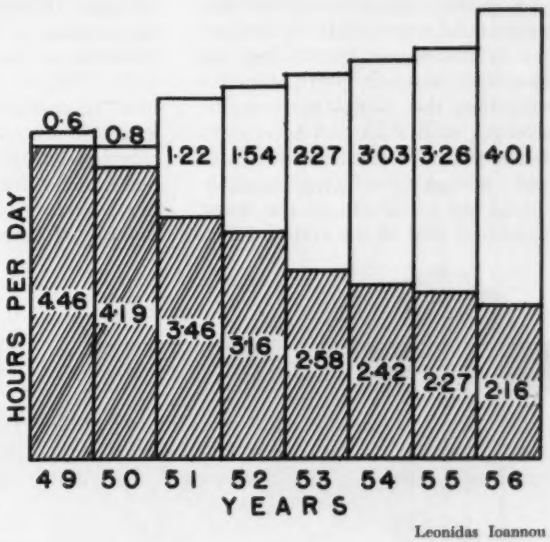


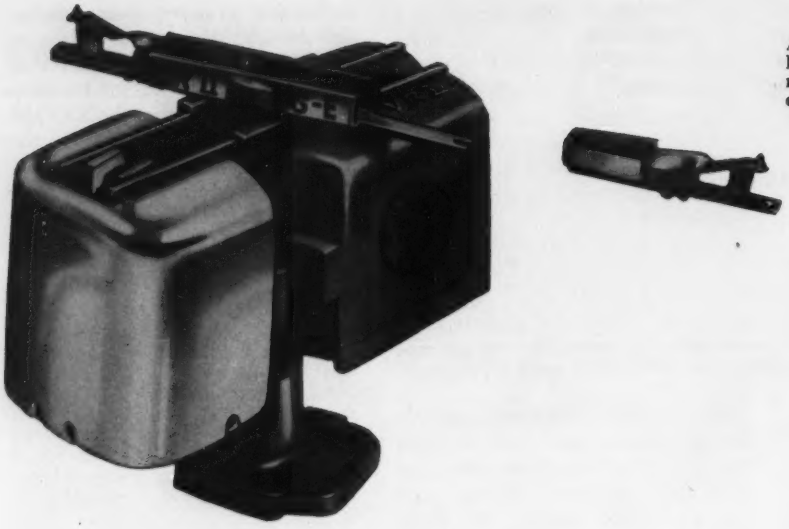
Leonidas Ioannou

Fig. 4: The growth of radio has been much slower than the growth of television. The shaded portion of each bar shows the number of homes with T-V. The total bar height shows the number of homes with radio. Data taken from *Broadcasting Yearbook*, 1957.



Leonidas Ioannou

Fig. 5: The public has turned from radio to television for entertainment. The shaded portion of each bar shows radio listening hours; the unshaded portion shows television viewing hours. Data taken from *Broadcasting Yearbook*, 1957.



General Electric

A dual stylus, having one needle for 78 RMP records and one for 33.3 RPM records, is often mounted on a single cartridge, as in the cartridge to the left.

PHONOGRAPH PICKUP CARTRIDGES

by Joseph F. Thomas, Jr. EP '63

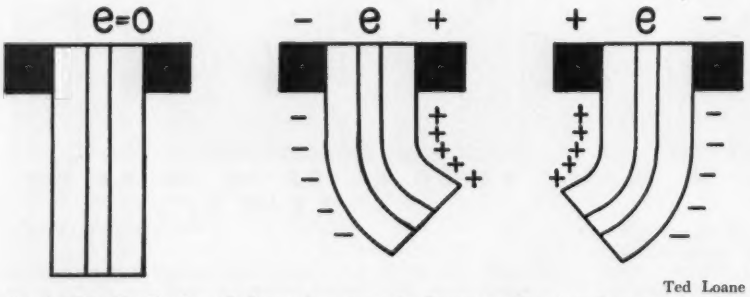
Many people today are enjoying high quality sound reproduction or high fidelity. Hi-fi, as it has come to be called, is a rapidly growing hobby, and a full appreciation of it requires a reasonable understanding of the operation of a high fidelity system. Such a system essentially consists of three main parts.

A pickup device translates the mechanical movements of the stylus in the record groove into an electrical current, an amplifier magnifies this signal to a useful strength, and a speaker reconverts this electrical current into mechanical motion producing audible sound waves. Perhaps the most important part of the system is the pickup cartridge, for it produces the original audio signal.

Piezo-Electric Cartridges

The earliest satisfactory cartridges were the piezo-electric crystal type. In these cartridges, the stylus was attached to a Rochelle salt crystal. When such crystals are distorted, they produce electrical voltages directly proportional to the amount of distortion imposed upon them. The movements of the stylus distort the crystal, and produce currents which correspond in amplitude and frequency to the signal originally recorded on the record. The successful operation of these cartridges was hindered by several adverse properties of the Rochelle salt crystals. They were seriously affected by changes in temperature and humidity, and they had an upper frequency limit of only ten kilocycles.

These difficulties were overcome in 1946, when the ceramic cartridge was developed. The basic operation was similar to that of the crystal cartridge, i.e., stylus motion caused production of output voltage proportional to the stress on the pickup element. The difference was in the material undergoing the stress. The old Rochelle Salt had been replaced by a ceramic element consisting of two layers of barium titanate separated by a metal member and coated with a thin layer of silver. The cartridges made by this new technique responded to the full range of audible sound, and were not affected by atmospheric conditions.



Ted Loane

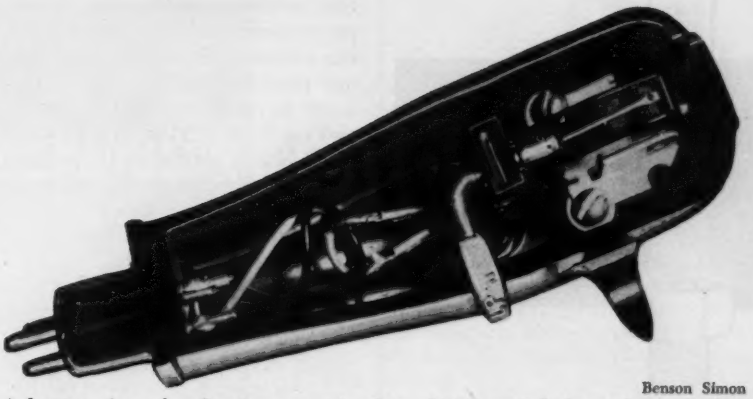
Fig. 1: The distribution of charge in a ceramic element under stress is proportional to the stress.

The Magnetic Cartridge

Not all cartridges, however, operate on the piezo-electric principle. The most popular hi-fi pickup today is the magnetic cartridge. Although it is more complex and produces a feebler output signal than the piezo-electric cartridge, it is the kind that is used in most hi-fi phonograph systems.

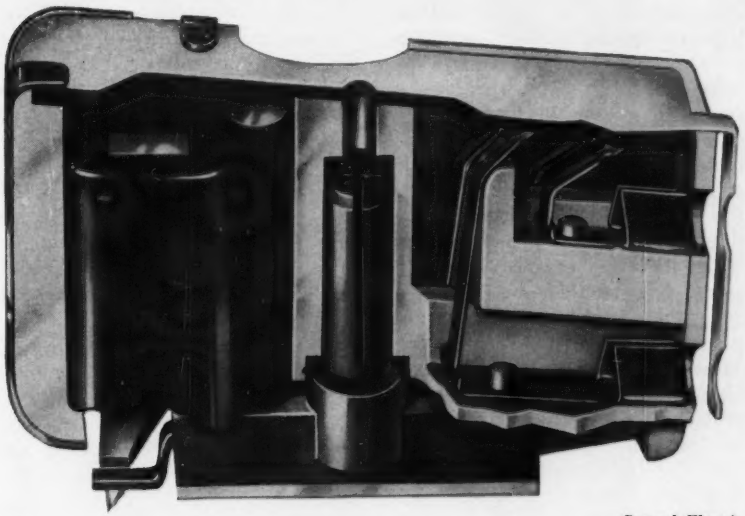
The magnetic cartridge is based on the principle of electromagnetic induction which states that an electrical current can be induced in a conductor if that conductor is made to move through a magnetic field. There are several mechanical systems which can be used in the cartridges to produce this effect.

Variable reluctance cartridges produce a current by varying the reluctance of a magnetic circuit. This is done by changing the size of an air gap in the circuit, which varies the magnetic field, and, in turn, induces voltage in a coil encircling a part of the circuit. Such a circuit is analagous to an electrical circuit consisting of a battery and a resistance in series. A change in the resistance will produce a corresponding change in the current. These circuits are illustrated in Fig. 2.



Benson Simon

A bottom view of a Sonotone ceramic piezo electric crystal shows the method of mounting it in a Gerard changer shell.



General Electric

This cross section of the General Electric single stylus magnetic cartridge illustrates (at right) the method of mounting the stylus in relation to the moveable magnetic core.

In the construction of the variable reluctance cartridges, two windings are connected in series on a magnetic core. The cartridge is assembled so that the movements of the stylus will move a metal element in the air gap. A simplified schematic diagram of the cartridge is shown in Fig. 3.

A second way of utilizing the principle of electromagnetic induction is in the dynetic system. The cartridge employs a moving magnet in a fixed coil. The magnet is attached to the stylus by a magnesium beam which causes rotation of the magnet on a vertical axis. This system allows the cartridge to have very high compliance. Compliance is the ease with which the needle can be moved, and is expressed in cm/dy. It is an important characteristic of phonograph cartridges.

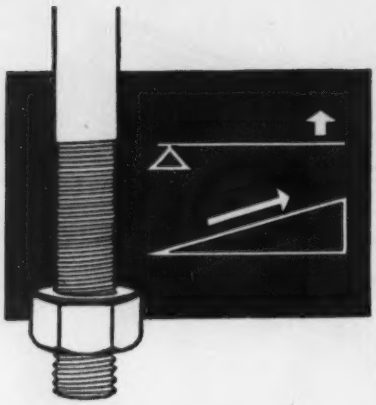
Output and Equalization

While magnetic and ceramic cartridges both perform the same basic function, there are two major differences in their operating characteristics that must be provided for in the hi-fi system. The first is the strength of the signal produced. It was stated earlier that the signal from the pickup must be amplified in order to drive the speaker. If a ceramic cartridge is used, a simple power amplifier is sufficient for doing this job. This is not the case, however, with a magnetic cartridge. The signal from a magnetic cartridge is many times weaker than the signal from its ceramic counterpart. A power amplifier alone could not amplify the signal enough to drive a speaker; a preamplifier, therefore, must be installed between the cartridge and the power amplifier to boost the output signal to a level comparable to that from a ceramic cartridge.

The second difference is the "equalization" required for the cartridges. The current produced by

Benson Simon

This bottom view of a Shure dynetic cartridge shows the standard four lead mounting enclosure.



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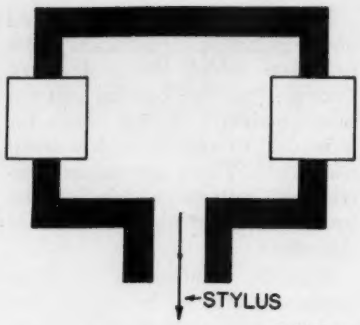
the ceramic cartridge is directly proportional to the amplitude of the motion of the stylus. The voltage produced by the ceramic element is unaffected by frequency, and no "equalization" is necessary. The voltage produced by a magnetic cartridge, however, is directly proportional to the velocity of the stylus. Since the stylus must move ten times faster to follow a ten kilocycle note than a one kilocycle note, the voltages produced differ by a factor of ten. Since this completely distorts the audio signal, the voltages must be corrected for frequency, or "equalized," during the preamplifying stage.

Radio Cartridges

While piezo-electric and magnetic cartridges are the two main types on the market today, a group of radio cartridges is being developed. In these cartridges, a small RF voltage is generated inside the cartridge and is then modulated by the motions of the stylus. In the "AM" type, a vane on the stylus assembly varies the inductance of a coil which is part of an RF oscillator. In this way a signal is generated. In the "FM" type, the stylus is attached to one plane of an electrical condenser. Movement of the stylus causes a change in the capacitance of the condenser. The FM cartridge has an excellent frequency range and has very low distortion. It is not in wide use however, due to circuit complications.

Stereo

The cartridges discussed so far are useful for playing monophonic records only. On stereo records, a different sound track is recorded on each side of the record groove. These sound tracks must be reproduced through separate amplifier and speaker systems to create the stereo effect.



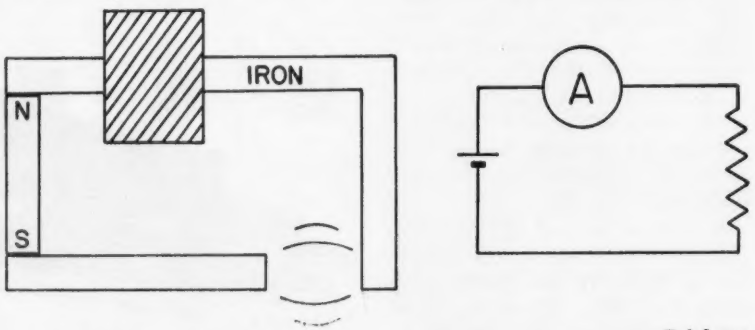
Ted Loane

Fig. 3: Operational variable reluctance type cartridge.

The fact that the two separate sound tracks are placed on opposite sides of the same record groove obviously will cause a great problem in cartridge design. The same basic electrical principles are utilized, but ingenious mechanical systems are used to separate the two sound channels.

First the cartridge must resolve the three dimensional motion of the stylus into two components. The cartridge must then translate these motions into two electrical currents.

In one type of stereo cartridge, the stylus is fastened to a lever. The other end of the lever is a rectangular assembly containing four hard jewel pivots. The pivots are coupled to yokes fastened to the generating coils. When the stylus of this mechanism is placed upon a record, the motion from the inner wall of the record groove results in a rotation of the inner coil only. The motion from the outer wall of the groove turns the outer coil. In operation, these motions take place at very high speeds, and produce the two separate audio channels.



Ted Loane

Fig. 2: The variable reluctance magnetic circuit and its electrical analog.

MEET BURNELL RICHARDSON AND DICK MASLOWSKI

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Dick got his B.S.E.E. degree from Michigan in 1956 and came straight to Michigan Bell. He is currently engineering and administering a program to utilize new, transistorized repeater (amplifier) equipment.

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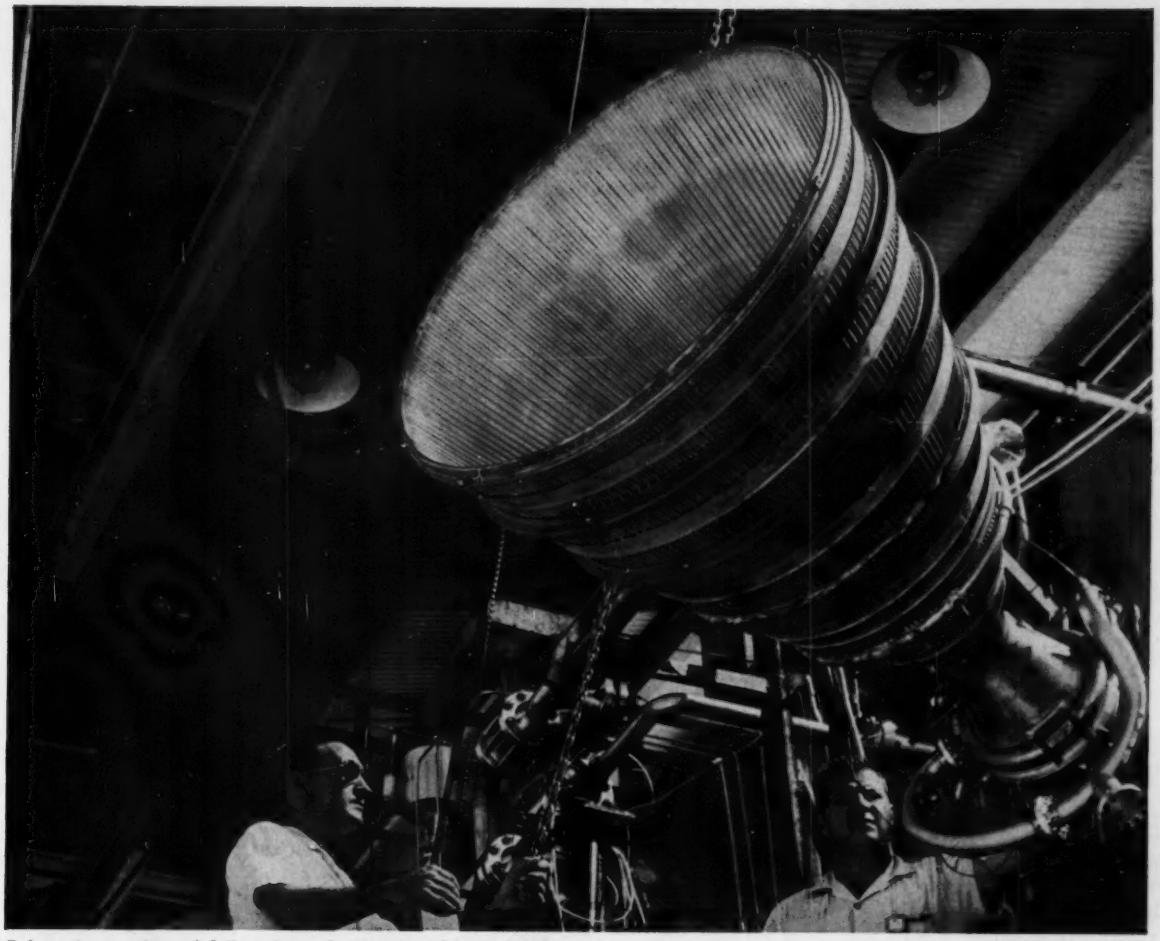

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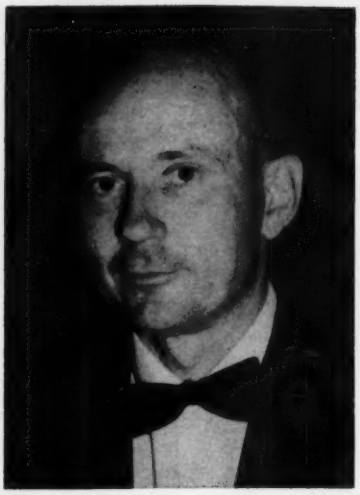

S. D. Teetor

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students, and to establish closer relationship between the College and its alumni."

THE PRESIDENT'S LETTER—

THE FOURTH DIMENSION

To those of you who are not acquainted with the terminology "Fourth Dimension", let me explain that fourth dimensional work means doing something a little bit over and beyond the work which is actually required. For example, a man who takes his own time and attends night school to obtain his Masters Degree participates in fourth dimension work. The same is true of a man who writes technical articles on his own time and his own initiative. Examples of fourth dimension work could continue along in the same vein as previously mentioned, but there is no sense in taking up the space available to me here to cite many examples. The big thing is that how many of us, both in college and in our business life, do more than the minimum necessary. For example, being a commuter myself and living approximately 50 miles from New York City, my place of business, I well realize what a great temptation it is to pick up the newspaper or a magazine, and to put all technical thoughts out of my mind. However, instead I take this train time to mull over and think out a problem that has arisen during the course of the business day. In the long run the man who does take time for this extra-curricular application of his mind does enjoy the "fruits of the harvest" ultimately, even though in many cases it may simply be the satisfaction of knowing that he has done more than is required to simply exist or eke out a living.

In closing, what better fourth dimension activity could any graduate Cornellian think of than the activity of this Society? Again let me urge all that are within a reasonable distance of the meeting points of the Society to attend as many of the Society functions as they can.

STEPHEN D. TEETOR '43
President

ALUMNI ENGINEERS

Kraig Brigden, B.E.E. '52, recently joined the staff of Thompson-Ramo-Wooldridge Products Co. in Los Angeles where he is working in data handling and market systems involving the use of computers. Mr. Brigden was with Space Technology Laboratories before joining Thompson-Ramo-Wooldridge. He also has done graduate work in electrical engineering at the University of Pennsylvania.

George H. Lockwood, M.E. '43, has been appointed manager of development and research of Heald Machine Co., Worcester, Mass. He had been serving as supervisor of grinding engineering and had also been in charge of special projects.

William A. Robinson, M.E. '06, has retired after fifty years of manufacturing, thirty as superintendent and president of Charter Gas Engine Co. and twenty as principal owner of Charter Wire Products.

Henry G. Warnick, M.E. '24, is now supervising engineer in the Westchester area for New York Telephone Company. He has been with the Company thirty-one years.

William P. Bamford, C.E. '33, has been appointed director of glass specifications for Libby-Owens-Ford Glass Co., Toledo, Ohio. He joined the Company in 1935, and became assistant plant manager at Rossford, Ohio, in 1956.

Alumni News

William P. Bamford

Martin Goland, M.E. '40, has been elected president of Southwest Research Institute, San Antonio, Texas. He joined the organization as chairman of the engineering mechanics division in 1946 and was made director of engineering sciences in 1950. He is chairman of the committee on structural dynamics of the National Aeronautics and Space Administration and editor of *Applied Mechanics Review.*

Alumni News

Martin Goland

W. Dean Wallace, M.E. '40, is now director of corporate development for Porter-Cable Machine Co., Syracuse.

E. Kenneth Leins, B.Chem.E. '47, has taken on a new assignment in the branch sales office of Solvay Process Division of Allied Chemical Corp. in New Orleans. Mr. Leins went into the Solvay technical service in 1952 and was made production section manager in 1956. He has also been assistant general manager, technical service. Now he will cover Louisiana and southern Arkansas for the Solvay sales department.

Winfield Shiras

Winfield Shiras, B.E.E. '48, has been named vice president and general manager of Telex, Inc. Telex produces electronic systems for industrial and military applications and precision components for commercial and industrial use. Telex is also a leading manufacturer of hearing aids.

Mr. Shiras had been with Westinghouse Electric Corporation for nine years, having held a number of supervisory and executive positions. These included the posts of manager of materials and services for the Corporation's Meter, Instrument, and Relay Division in Newark, New Jersey and director of purchases for the General Products Divisions. He also served two years as internal management consultant on special assignments to corporate top management.

After graduating from Cornell in 1948, he received his Master's Degree in business administration from Harvard Business School in 1950.

Robert W. Engelbert, B.C.E. '49, has been appointed assistant chief engineer of the southern steel district of Republic Steel Corp. He was transferred from the Buffalo division to Gadsden, Ala.

Lawson F. Singer, B.E.E. '49, has been promoted to engineering section head for radar systems in

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the search radar engineering department of the surface armament division of Sperry Gyroscope Co.

Ted Roehner, B.Chem. '24, has left his fifteen-year post as manager of technical service labs, Socony Vacuum Oil Co., to take up new duties at headquarters as manager of the technical service division for the research department of his company. Under his new position the technical service function is broadened and covers both Paulsboro and Brooklyn. Upon graduation, he spent the next six years in Chile as test engineer and assistant chief chemist with Braden Copper Co. He is chairman of the National Lubricating Grease Institute technical committee and was formerly chairman of the American Society of Lubrication Engineers technical committee and of Section III of ASTM Technical Committee G. He is a member of the American Association for the Advancement of Science, American Chemical Society, American Ordnance Association, American Petroleum Institute, Cornell Engineers' Club, and Sigma Xi. In 1945 Mr. Roehner received the Naval Ordnance Development Award and in 1952, the National Lubricating Grease Institute Award.

Donald Griffin, B.M.E. '51, is a senior engineer at Bettis Atomic Power Division of Westinghouse Electric. Mr. Griffin received the Ph.D. in engineering mechanics at Stanford in June.

Thomas C. Borland, M.E. '35, has been nominated by Cornell University for the 1959 *Sports Illustrated* Silver Anniversary All America Award. At Cornell he was guard on the varsity football team for three years and rowed on varsity crew for two years, becoming captain his senior year.

Upon graduation from Cornell in 1935, he joined Pan American Petroleum Corporation (then Stanolind Oil and Gas Co.) in East Texas as a roustabout and progressed through engineering channels.

Mr. Borland joined the Navy in 1942 but returned to inactive duty in December, 1945, having attained the rank of lieutenant commander.

He rejoined Pan American as a

Sports Illustrated

Thomas C. Borland

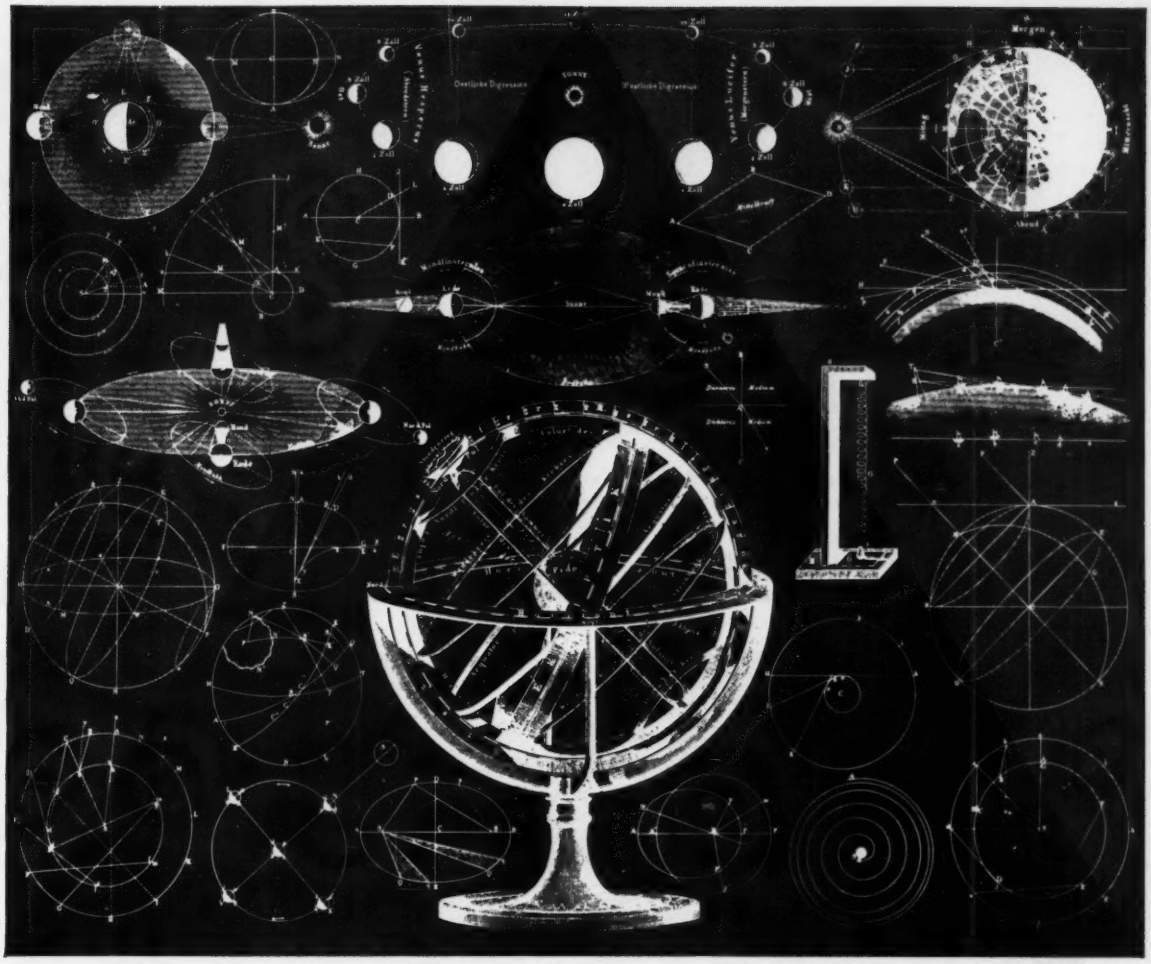
member of its general office engineering staff in Tulsa in February, 1946. In June, 1947, he was named district engineer of the Houston, Texas, district; later that same year he became assistant division engineer for the Texas-Louisiana Gulf Coast division at Houston, and in July, 1948 he advanced to division engineer.

He moved to Oklahoma City in January, 1951, as assistant division production superintendent for the Central division. He was transferred to the Canadian division at Calgary in May, 1955, and was promoted to division production superintendent.

In June, 1958, he was elected vice president-production and a director of Pan American International Oil Company, a subsidiary of Pan American Petroleum Corp.

Still sports-minded, Mr. Borland now plays tennis and golf and also swims. He is an active member of the American Petroleum Institute and the Pan American Society of the United States, Inc.

On November 16, 1959, the Chicago Chapter of the Cornell Society of Engineers heard an excellent talk on the missile defenses in the Chicago area given by Brigadier General Frederick W. Ellery. The following officers were elected for the year 1959–1960: president, John P. Gnaedinger, B.C.E. '47; vice president, John Ehret, B.M.E. '51; secretary, Albert E. Pyott, B.M.E. '53; treasurer, James Judd, '44.



Guided tour of the solar system

The new NASA Thor-boosted research rocket, DELTA, now being constructed by Douglas, will set up big signposts for further space explorations. Combining elements already proved in space projects with an advanced radio-inertial guidance system developed by the Bell Telephone Laboratories of Western Electric Company, DELTA will have the versatility and accuracy for a wide variety of satellite, lunar and solar missions. Douglas insistence on reliability will be riding with these 90 foot, three-stage rockets on every shoot. At Douglas we are seeking qualified engineers to join us on this and other equally stimulating projects. Write to C. C. LaVene, Box B-600, Douglas Aircraft Company, Santa Monica, California.

Maxwell Hunter, Asst. Chief Engineer—Space Systems, goes over a proposed lunar trajectory with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

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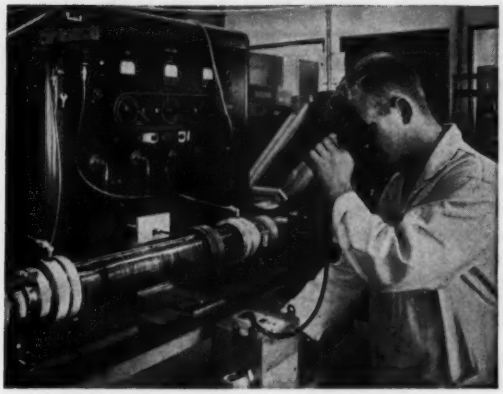

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an atomic clock in orbit

To test Einstein's general theory of relativity, scientists at the Hughes research laboratories are developing a thirty pound atomic maser clock *(see photo at left)* under contract to the National Aeronautics and Space Administration. Orbiting in a satellite, a maser clock would be compared with another on the ground to check Einstein's proposition that time flows faster as gravitational pull decreases.

Working from the new research center in Malibu, California, Hughes engineers will develop a MASER (Microwave Amplification through Stimulated Emission of Radiation) clock so accurate that it will neither gain nor lose a single second in 1000 years. This clock, one of three types contracted for by NASA, will measure time directly from the vibrations of the atoms in ammonia molecules.

Before launching, an atomic clock will be synchronized with another on the ground. Each clock would generate a highly stable current with a frequency of billions of cycles per second. Electronic circuitry would reduce the rapid oscillations to a slower rate in order to make precise laboratory measurements. The time "ticks" from the orbiting clock would then be transmitted by radio to compare with the time of the clock on earth. By measuring the difference, scientists will be able to check Einstein's theories.

In other engineering activities at Hughes, research and development work is being performed on such projects as advanced airborne systems, advanced data handling and display systems, global and spatial communications systems, nuclear electronics, advanced radar systems, infrared devices, ballistic missile systems... just to name a few.

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COLLEGE NEWS

Edited by R. A. Stern, EE '63

PHYSICIST CLIMBS MOUNTAIN TO TEST FOR NEW PARTICLE

A 33-year-old Cornell University nuclear physicist, whose hobby is mountain climbing, disclosed that he struggled 10,600 ft up a mountain with a colleague to investigate the alleged discovery of a new atomic particle by Russian scientists.

Jay Orear, an associate professor at Cornell who studied under the great Enrico Fermi, is also investigating in the laboratory the existence of another particle claimed to have been discovered recently by a Communist scientist.

A paper published in *The Physical Review* by Associate Professor Orear reported evidence compiled by him and colleagues against the existence of the "mass-500 particle," claimed to have been discovered by Russian physicists Alikhanian, Shostakovich, Dadain, Federov and Deriagin. The Russians had published their findings in the *Journal of Experimental Theoretical Physics*, a Soviet publication.

Precisely duplicating the work of the Russians, the Cornell researcher scaled Mt. San Jacinto in California to an altitude of 10,600 ft. The Russian team had conducted their research at exactly the same altitude in the U.S.S.R., according to the Russian report.

"Particles were detected by a method which would have established the existence of a mass-500 particle on the basis of a single occurrence. The non-occurrence of such particles failed to confirm and, in fact, contradicted the particle abundance reported by Alikhanian and his co-workers," Associate Professor Orear said.

His current effort is aimed at investigating the claim of a Communist scientist who revealed that he had discovered a new particle by using the world's largest known atom-smashing machine at Dubna near Moscow.

Associate Professor Orear is the principal scientist involved in Cornell University's receiving a two-year research grant of $99,400 from the National Science Foundation.

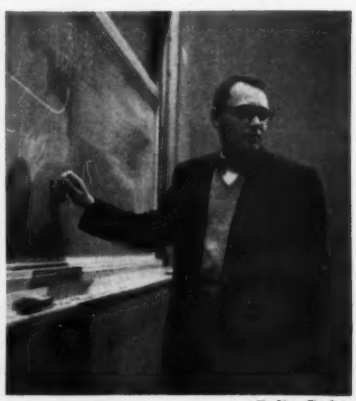
He said that some of the money that has been granted will be used in exploring the Mu meson, a particle mystifying to nuclear physicists because it behaves like a normal electron although it is 210 times as heavy. The interactions of Mu mesons with silver and bromine nuclei will be studied by bombarding nuclear emulsions with Mu mesons.

According to the Cornell nuclear physicist, "The laboratory investigation to which the Mu will be submitted should either reveal conclusive differences between it and a normal electron, or convince us even more that it behaves in all respects like a normal electron."

"In the past, lead has been used as a vehicle to gather data on the nuclear interaction of Mu mesons. We have calculated that our use of silver and bromine will permit deeper penetration inside the nuclei by the Mu mesons and perhaps enable us to detect behavior heretofore unknown."

CLARK DESCRIBES RESEARCH PLANS FOR NEW REACTOR

In a recent lecture, Professor David D. Clark of the department of engineering physics outlined plans for research and teaching with the new Cornell Reactor Center. Construction of the Center is to begin this spring.



Delia Corkey

Professor David D. Clark of the Department of Engineering Physics lectured recently on the research and instruction to be carried on at the new Cornell Nuclear Reactor Center.

The facilities are designed for instruction and for research by faculty members and graduate students. Professor Clark emphasized that there is a need for a reactor facility to be used for purely academic research only. He said that work at the reactors owned by the government and by various industrial concerns is generally aimed at solving specific problems encountered on specific projects. Research at the Cornell reactor is to center around problems of general theoretical interest.

The Center will contain three major facilities, a gamma irradiation cell, a zero-power reactor, and a Triga swimming pool reactor. The gamma source produces very little heat and it will be used primarily to study certain chemical reactions.

Professor Clark stated that the zero-power reactor is designed to operate at a maximum power output of 10 w. The neutron flux is very low and consequently none of the components get very radioactive; they can therefore be taken apart and rearranged easily. Thus it will be a very convenient instrument in research for which high power levels are not necessary.

The swimming pool reactor is, according to Professor Clark, designed to operate at about 10 kw. He asserted that a reactor producing a great deal of heat is very difficult to work with and is inconvenient for research. Professor Clark explained that the Cornell reactor will, however, be capable of short "pulses" up to 1000 megawatts for 20 to 30 milliseconds. He stated that the neutron flux during these pulses will be greater than that in any steady-state reactor, real or contemplated. He explained that the large neutron fluxes allow the addition of several neutrons to stable nuclei. Reactions of these highly unstable isotopes are similar to those which take place on stars.

The undergraduate program for engineering students wishing to specialize in reactor technology consists of courses in the following subjects: atomic physics, nuclear and reactor physics, nuclear measurement laboratory, fuel processing

and reactor shielding, nuclear reactor materials, and heat transfer.

UNIVERSITY PROVIDES LAND FOR INDUSTRY RESEARCH WORK

A research center, operated by private industries in cooperation with the University, is to be constructed on University-owned land adjacent to the Tompkins County Airport.

The new General Electric Advanced Electronics Center building is now under construction and is scheduled for completion in 1960. It is expected that as more industries arrange for research facilities at the Park, a supporting residential community will rise nearby. This community will be formulated and grow according to a design prepared by the staff of the department of city and regional planning of the College of Architecture. Contribution to the design will be made by a committee representing a number of divisions of the University.

The financing of buildings for industry research purposes may come either from the industry or from other sources. Cornell stipulates that the establishments which will form its Industry Research Park are restricted to research facilities rather than facilities for production purposes.

"Cornell University is strengthening its own ability for partnership by establishing near its campus the Cornell University Industry Research Park," stated Deane W. Malott, president of the University. "This is a new, though not untried, venture—and one for which we have high hopes for a close relationship of mutual advantage with industrial enterprises interested in research and the University facilities which we stand ready to extend."

MACKEY DISCUSSES USES OF SOLAR RADIATION

Recently Professor C. O. Mackey, head of the department of thermal engineering, delivered a lecture on new applications of solar energy. He discussed radiant energy traps; the domestic use of solar energy for heating; and solar heat exchangers, refrigerators, and stills. Professor Mackey also commented on Cornell's interests in solar energy.

At the beginning of his lecture, Professor Mackey stated that the equilibrium temperature of an irradiated body could be varied from 40 to 300 F by the application of various metallic coatings. For example, a nickel-plated object can approach 300 F under solar radiation while a black body is at equilibrium at only 40 F under the same amount of irradiation.

He pointed out that glass may be used as an "energy trap" since it transmits radiation in the visible range but does not transmit radiation of long wave length coming from low temperature sources. Thus the radiation emitted inside a glass "greenhouse" is not transmitted to the outside while the solar energy comes through the glass easily. Professor Mackey pointed out that for maximum efficiency, any absorbing device should be mounted at an angle equal to the latitude of the location. But if more heat were desired during the winter months, for example, the angle could be changed to compensate.

Solar energy can be concentrated by parabolic reflectors. Professor Mackey mentioned that Army searchlights make excellent solar reflectors, having a concentrating power of 46,200.

Professor Mackey discussed the possibilities of the domestic use of solar energy. In Australian experiments, 640 Btu per sq ft per day was collected in a unit designed to heat water for domestic use. The "Denver House" with a 32 sq ft collecting surface produced 25 per cent of the daily heat requirement. Air circulating behind glass was heated by the sun; a large column filled with 10 tons of gravel acted as a heat exchanger.

Professor Mackey discussed solar refrigerators as well as solar stills,

The General Electric Advanced Electronics Center, to be completed in 1960, will be the first building in Industry Research Park. The Center is being constructed on University-owned land near the Tompkins County Airport. Scientists from the University will join those from General Electric on research to be performed with these facilities.

devices used for condensing water vapor from the air by cooling. The present limitation on both of these devices is their cost. The solar still would, naturally, be a feasible water source only in desert regions where the water would otherwise have to be imported.

At the close of his lecture, Professor Mackey also mentioned Cornell's interest in solar energy. The University recently purchased an Army searchlight, the reflector of which is to be used in metallurgical studies.

ME SCHOOL RECEIVES FIVE RESEARCH PROJECT GRANTS

Professor Howard N. McManus, Jr., of the department of thermal engineering in the Sibley School of Mechanical Engineering, has been awarded a grant of $35,700 for a 3-year period by the National Science Foundation for a research project entitled, "Momentum and Energy Transport between Plates of Unequal Roughness."

This basic research study will be concerned with the heat transfer, the velocity profiles, and the drop in pressure that occur when air flows between two surfaces of unequal roughness.

Professor Benjamin Gebhart, of the thermal engineering department in the Sibley School, has just received a grant of $19,200 for a 2-year period by the National Science Foundation for a research project, "Transient Natural Convection Process."

In addition to the new grants listed above, several extensions of existing research contracts have been received.

Professor H. N. McManus, Jr. received $14,000 more on his U.S.A. Ordnance Project, "Investigation of Liquid Distribution and Surface Character in Horizontal Annular Two-Phase Flow."

Professor Robert E. Bechhofer of the industrial and engineering administration department received an extension on the grant for his U.S. Air Force project, "Statistical Multiple Decision Procedures." Professor Bechhofer has directed this project since 1953 with a total allocation of funds from the Air Force of approximately $122,000.

Professor Richard W. Conway, industrial & engineering administration department, received an extension on his Naval Ordnance Research project, "Investigation of Digital Systems Simulation."

HANS BETHE HONORED BY FRANKLIN INSTITUTE

Hans A. Bethe, professor of physics at Cornell, received the Franklin Medal from Wynn L. Le Page, president of the Franklin Institute in Philadelphia. He was cited for "his many profound investigations which have contributed significantly to our understanding of the physical universe from nuclei of atoms to the interior of the stars." After receiving the award, the highest given by the Institute, Professor Bethe addressed the 400 attending the ceremony on "Fundamental Particles."

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—Physics and Philosophy, 1942

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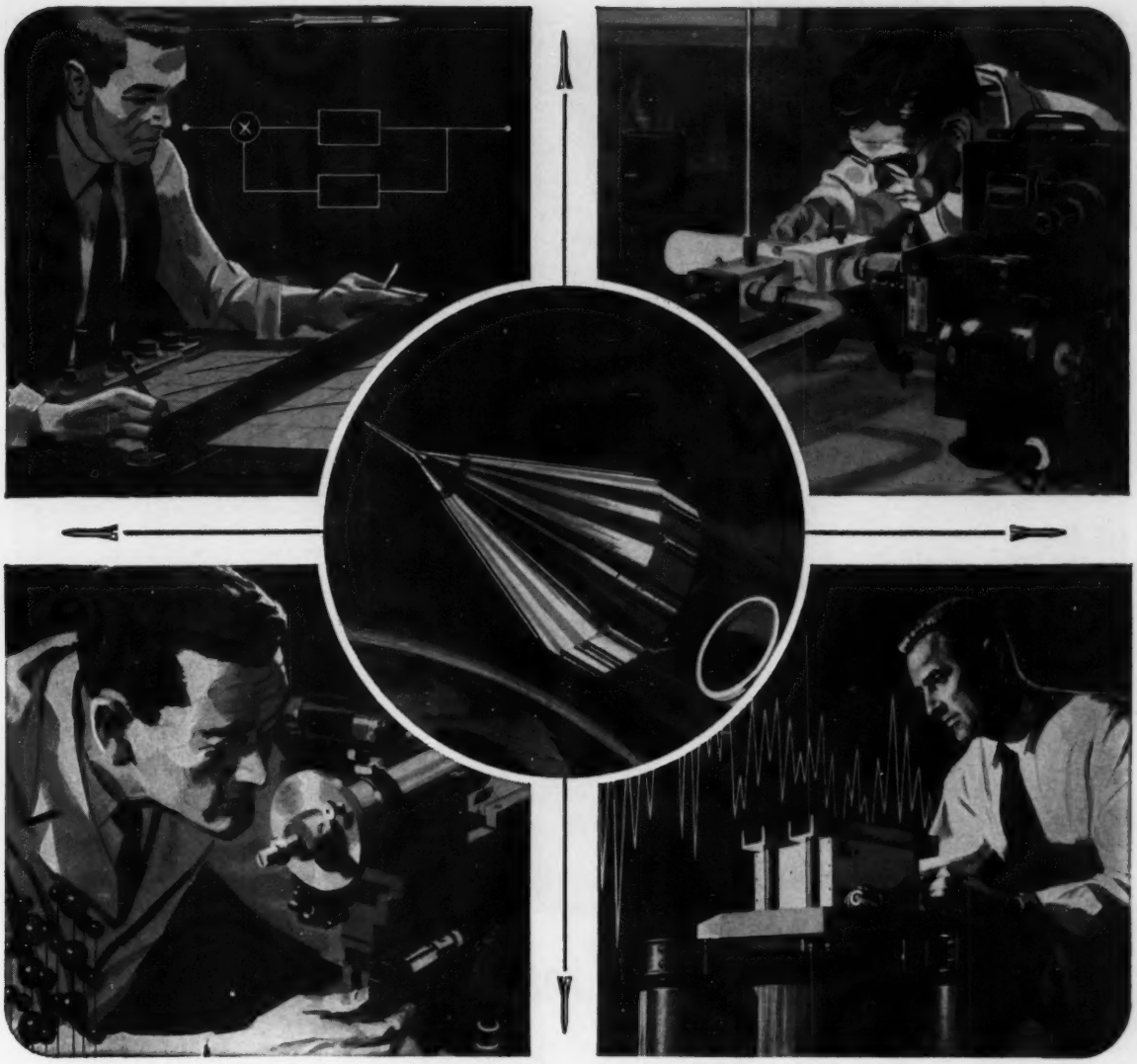

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DR. W. H. PICKERING, Director, JPL

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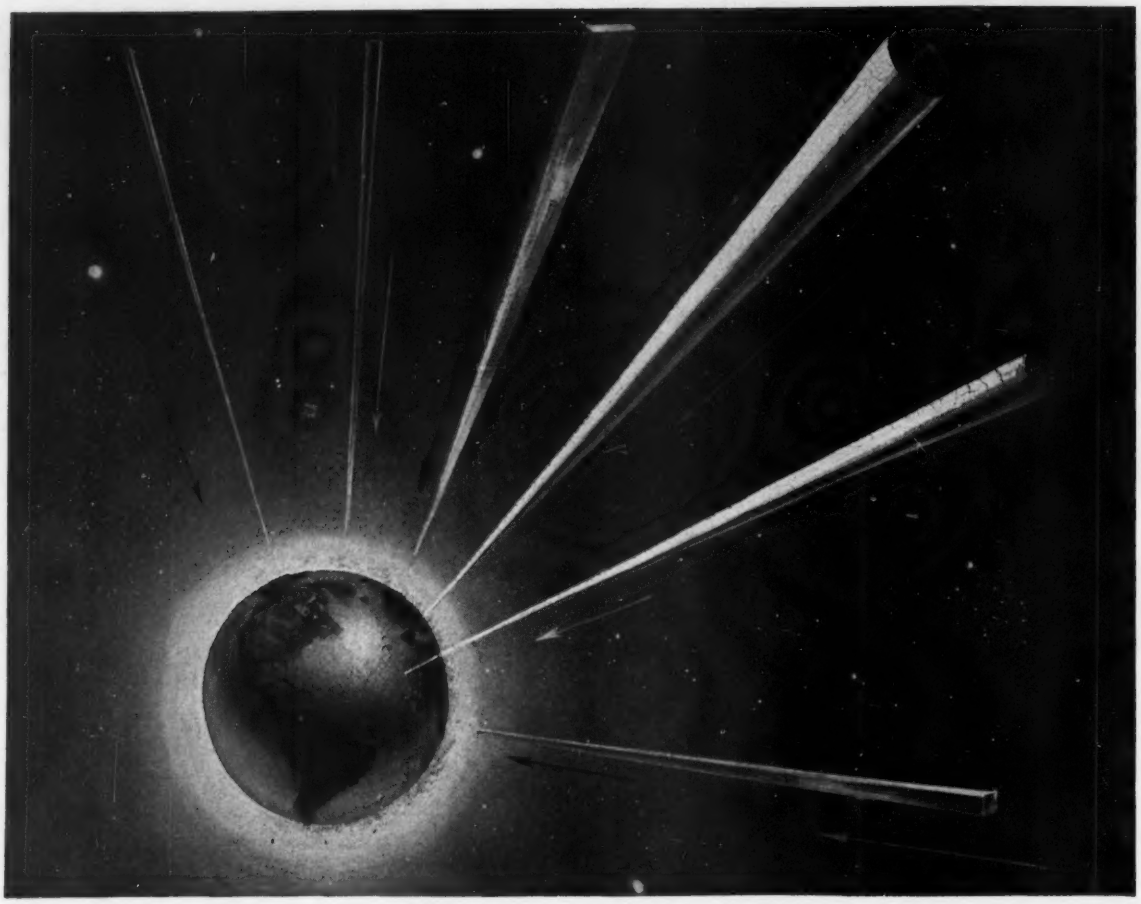

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TECHNIBRIEFS

Edited by D. J. Martin, ME '62

NEW LIQUID ROCKET FUEL DEVELOPED BY NAVY

Civilian scientists of the Bureau of Aeronautics, U.S. Navy Department have developed a new type of liquid rocket monopropellant, which combines a high specific impulse with handling safety.

Motor tests have demonstrated that 93–94% of the high theoretical impulse can easily be attained with chamber less than 50 in. long.

The propellants are extremely stable, and hence safe to handle. Heating them to 320 F for 48 hours does not cause them to explode or decompose appreciably, and they are apparently completely indifferent to ordinary mechanical shock. It takes a high order explosion adjacent to a sample to induce a detonation.

They do not deteriorate in storage, and are so slightly corrosive that they can easily be prepackaged. The raw materials are commercially available in ample quantity, and the cost of the monopropellant, when made in quantity, is expected to be no more than five or six dollars a pound.

NEW METHOD DEVELOPED FOR 'PRINTING' CIRCUITS

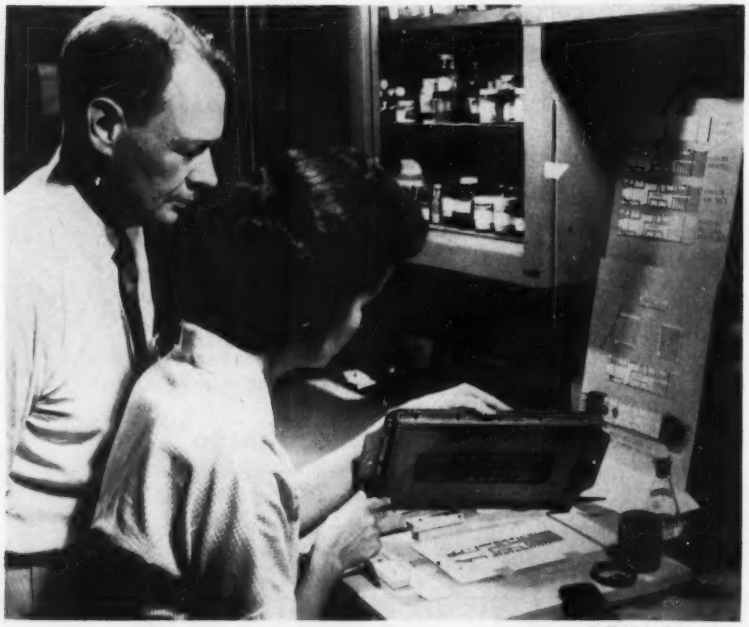
A new method for producing printed wiring directly on ceramic bases without the use of adhesives has recently been developed by Bell Telephone Laboratories. The basis of the new process, which uses standard silk screening techniques for forming the pattern, is a specially formulated copper-bearing paste.

In present methods of production, a sheet of copper foil is usually bonded to the ceramic or plastic base with an adhesive. The desired pattern is then produced by one of several methods usually involving the removal of undesired material. The bond of the copper to the base thus is dependent on the strength of the adhesive. It often fails during subsequent processing operations, such as soldering or assembly.

With the new process, a paste is prepared from a finely ground mixture of copper oxide and a special glass frit, blended with a standard silk screen printing vehicle. The paste is used to print the pattern on the ceramic, and the "card" is heat-dried to remove solvents. After drying, the card with its pattern is fired in air at 750 C for 20 min to burn off the printing vehicle. This operation leaves a non-conduction copper oxide pattern, ready to be reduced to metallic copper.

The second firing operation is conducted at 850 C for 30 min in a controlled atmosphere containing hydrogen, nitrogen, and oxygen. The hydrogen in the atmosphere reduces the copper oxides to metallic copper, while the oxygen prevents reduction of other oxides in the system and promotes good wetting of the glass frit and the ceramic. Without the oxygen present, a poor bond results.

Printed wiring cards prepared this way can be dip-soldered without bond failure, and without the use of corrosive fluxes. In tests of bond strengths, 20-gauge headed wires were attached to the pattern with an area contact of about .01 sq in. Bond failure did not occur until about 2000 psi tensile pull, and even then generally involved breaking out the ceramic rather than bond failure.



Bell Telephone Labs

A. W. Treptow and Miss Lucille Finneran examine the screen printed pattern produced using a newly-developed copper paste for circuits printed directly on ceramic bases. After drying, the printed ceramic "card" is fired in a two stage operation to burn off the printing vehicle, and to convert the copper oxide in the paste to metallic copper.

SPUTTERED RESISTORS INCREASE COMPONENT DENSITIES

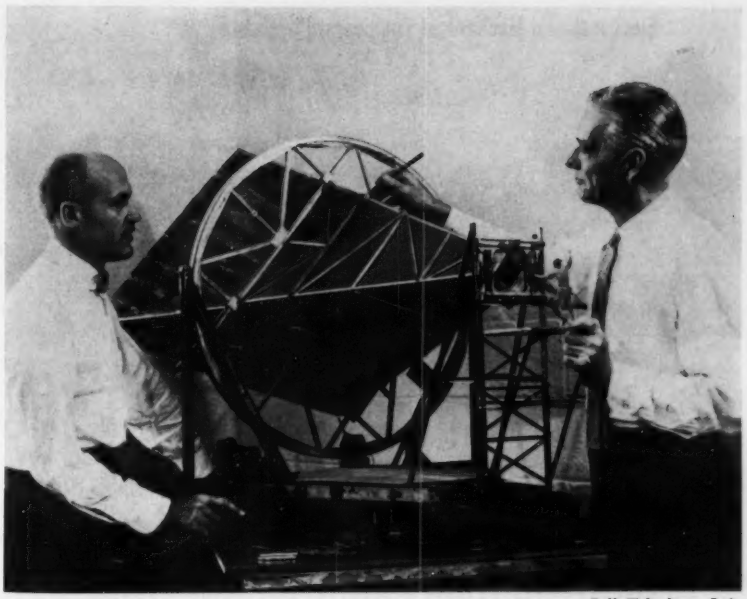
Sputtered thin-film resistors, formed from refractory metals such as tantalum and titamium, may be one of the more important developments in microminiature electronics. Such resistors can be produced on glass or ceramic bases in lines as narrow as 1 mil, spaced 1 mil apart, thus producing high resistance in a small area.

The miniature resistors owe their success to a high precision masking process, which makes it possible to produce the thin films in specifically restricted locations. An expendable copper mask is used for this operation.

In producing a resistor, an overall thin film of copper is first deposited on the ceramic or glass base, for example, by sputtering. Then, the desired pattern is etched into the copper surface by standard photoetching techniques, leaving the bare substrate exposed. Tanta-

lum, other refractory metals, or electrically useful alloys are then deposited onto the etched copper pattern, and the whole unit placed in an etching bath. The copper with its overlay of tantalum is removed, leaving behind only the tantalum which was in direct contact with the bare surface. Since the masks are extremely thin, fine detail is possible. Also, since the sputtered materials adhere to the substrate itself, support considerations are not necessary and complex patterns can be produced.

One of the most important aspects of the new development is the production of high quality capacitors and resistors from a single metal, cutting down the number of required operations. Also interconnections can be made simultaneously with the components, thus eliminating faulty interconnections and removing one of the greatest reliability hazards in miniaturized electrical circuitry.



Bell Telephone Labs

Engineers examine a model of the large horn antenna which will be used at the Bell Telephone Laboratories ground station for experimental communication via man-made satellites. When completed, the horn antenna will be about 50 ft in length, and the aperture will measure about 20 ft by 20 ft.

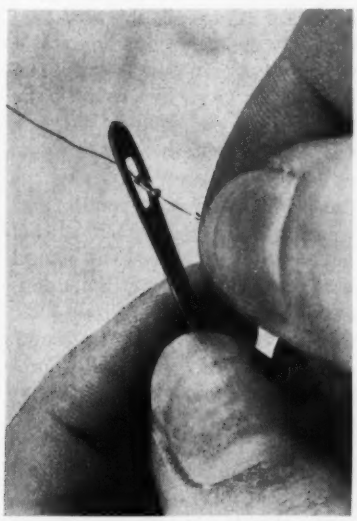
MINIATURE LIGHT BULB PASSES THROUGH EYE OF NEEDLE

The smallest incandescent lamp ever produced on an assembly line has been placed into production by Sylvania Lighting Products. The lamp is small enough to pass through the eye of a darning needle. The microminiature lamp has immediate applications in transistorized circuits in missiles, computers and electronic systems.

The body of the lamp is cylindrical with a nominal diameter of .040 in. Nominal body length is 0.125 in. The lamp leads are platinum in a diameter of 0.005 inches. The filament is 0.00025 in., less than one tenth the diameter of human hair. It consists of about thirty turns of tungsten wire.

The diminutive lamp can be seen in a normally illuminated room. Its light output is in the order of 100 millilumens at 1.5 v input. The efficiency of the lamp is approximately 1.5 lumens per watt.

Because it can be operated directly from the output of a transistor, the lamp will be used in many display devices consisting of a matrix of many lamps for such purposes as computer readout displays and arrays for animation.



Sylvania Electric Products

An incandescent lamp, so small it can be passed through the eye of a darning needle, has been placed in production by Sylvania Lighting Products.

TERMINAL WILL SEND RADIO MESSAGES VIA SATELLITES

An experimental ground station for sending and receiving telephone messages by way of man-made satellites is under construction by Bell Telephone Laboratories at Holmdel, N.J. The station could point the way to a network of terminals for sending phone calls and live television to distant parts of the world. These stations would "bounce" radio signals off dozens of "sky-mirror" satellites.

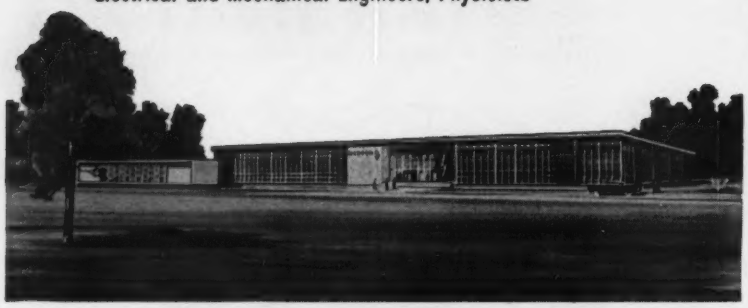
One of the projects at Holmdel will test the quality of radio signals transmitted between stations on opposite sides of the United States by means of reflections from a satellite. Although single telephone channels will be used in the experiment, the objective is to determine whether television's "broadband signals" (the equivalent of about 900 telephone channels) could also be transmitted. Such broadband signals cannot now be carried over present submarine cables, and cannot be transmitted directly by radio between widely separated points because the signals are blocked by the earth's curvature.

One of the initial and crucial problems in these experiments will be tracking speeding satellites precisely, and for this purpose Bell Laboratories will devise its own special equipment. Data predicting the "passes" of satellites will arrive in coded form and the new equipment will rapidly convert the information into a form suitable for controlling the antennas.

BOEING EXPERIMENTS PRODUCE INSTRUMENT LANDING SYSTEM

A new instrument landing system for aircraft is under development by Boeing Aircraft Company.

Electrical and Mechanical Engineers; Physicists



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far less than present systems in operation. The Boeing technique requires only the addition of two small units to automatic direction finding equipment (ADF receivers) currently used on most aircraft plus two radio "homer beacons" on the ground.

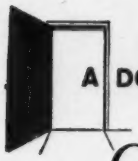
Present all-weather navigation, approach and landing systems require ground-based radar or very high frequency (VHF) radio navigational aids of the type costing millions of dollars each and normally found only at major improved fields. Because of its line of sight limitations, VHF radio transmission is extremely restricted at low altitudes, but low frequency signals tend to follow the earth's curvature which makes them ideal for low altitude communications.

One of the "homer beacons" would be placed on the centerline of the runway's departure end and while the other "beacon" would be placed at a known distance to left or right at the approach end. Both would transmit a steady, low frequency signal.

To operate with the beacons, the airplane's standard automatic direction finding receivers would be a special filter and coupler—both weighing less than 6 lb. The filter, after screening information coming out of the automatic direction finder, provides the system with a true heading. The coupler, a tiny but critically accurate "brain," then examines all available data and supplies the same intelligence to the pilot, except for altitude, that normally is given by ground-based navigational and landing aids.

Signals from the beacons are channeled through the new system to an instrument continuously showing the pilot his exact location in reference to the runway regardless of wind. The "third dimension," continual and exact altitude information, is supplied by the plane's radar altimeter while the automatic direction finding coupler reports constantly the number of feet remaining before touchdown.

Correlating his altitude and distance-to-touchdown information with what he sees on a visual display instrument, the pilot can bring his aircraft down safely without ever looking outside.



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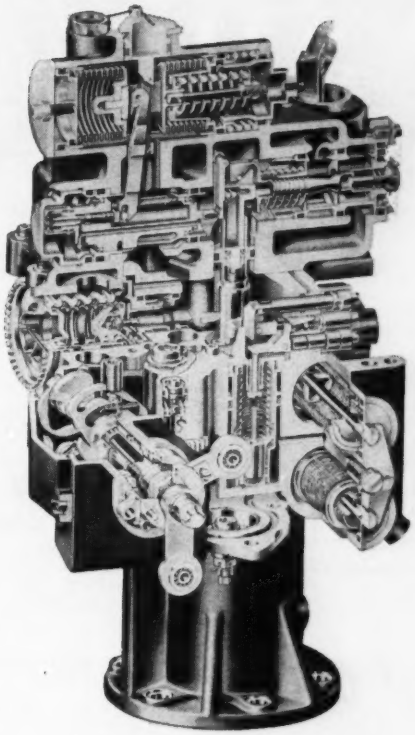

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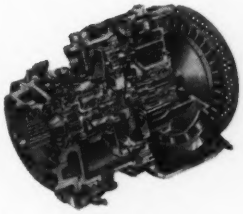

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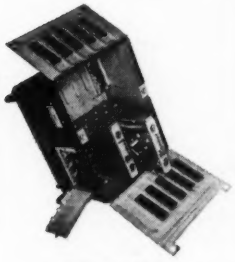

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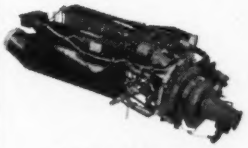

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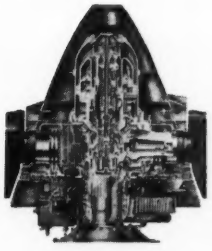

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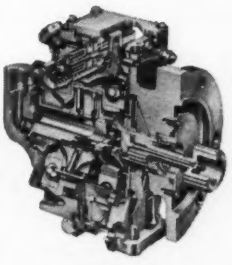

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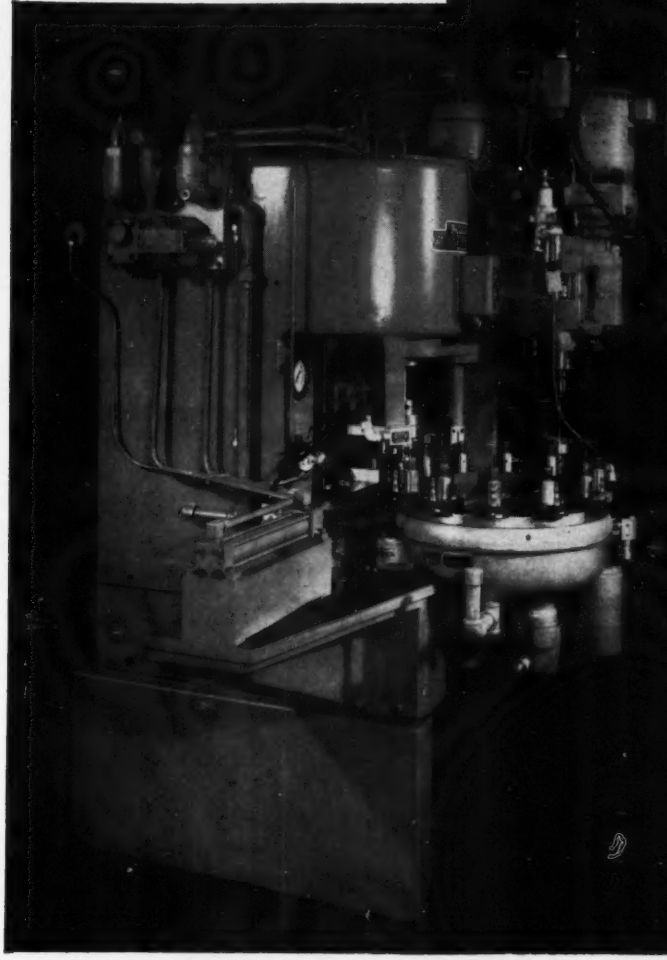

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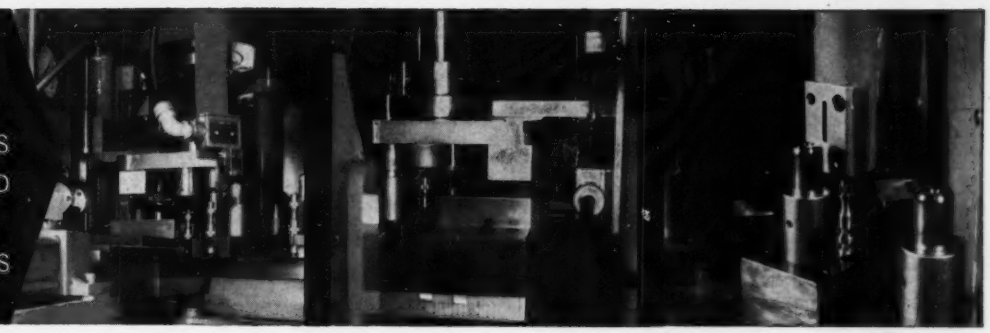

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STRESS *and* STRAIN...

Two stuttering blacksmiths had finished heating a piece of pig iron, and one placed it upon the anvil with a pair of tongs.

"H-h-h-h-h-h-h-h-hit, it," he stuttered.

"W-w-w-w-w-w-w-w-w-w-w-wh-where?" asked the other.

"Aw-h-h-h-h-h-hell, we'll have to h-h-heat it again, now."

• • •

Mama: "I'm glad to see you sitting so quiet while your father naps."

Junior: "I'm watching his cigarette burn down to his fingers."

• • •

The young lady eyed her escort with disapproval. "That's the fourth time you've gone back for more punch, Albert," she said coldly. "Doesn't it embarrass you at all?"

"Why should it?" the young man shrugged. "I keep telling them I'm getting it for you."

• • •

Mrs. Smith, seated in her living-room, heard the back door slam. Thinking it was her young son, she called: "I'm in here, darling. I've been waiting for you."

There was no answer for a moment then a strange voice faltered, "I'm sorry, but I ain't your regular milkman."

• • •

Someone has observed that it takes a student twenty minutes longer to say what he thinks than to tell what he knows.

• • •

A woman looks upon a secret in one of two ways. Either it is not worth keeping, or it is too good to be kept.

• • •

Two morons each had a horse, but they couldn't decide which belonged to whom. So they cut the mane off one to differentiate, but it soon grew back. Next they cut the tail off one, but that also grew back. Finally they measured them and found that the black one was four inches taller than the white.

For Chem E.'s: We've often heard it said that gasoline and alcohol don't mix. Actually, they mix, but they just don't taste good.

• • •

Probably the reason that God made woman last was that he didn't want any advice while creating man.

• • •

Three eminent doctors were bragging among themselves one day. Said the first, "I grafted an arm on a fellow and now he plays tennis like a pro." Said the second, "I grafted a leg on a man and now he runs on the Olympic team." The third man took the cake with, "I once grafted a smile on a jackass and now he is a Congressman."

• • •

Guest: "Why does your dog keep watching me like that?"

Host: "I guess it's because you've got the plate he usually eats from."

• • •

Lieutenant (in the mess hall, roaring with indignation): "Who told you to put these flowers on the table?"

Sergeant: "The Colonel, Sir."

Lieutenant: "Pretty, aren't they?"

• • •

The bus was crowded when the young lady got on and a soldier attempted to rise. She pushed him back gently and he tried to rise once more.

"No, no, thank you," she murmered, pushing him back again.

"Please let me get up, lady," he protested. "I'm two blocks past my stop now."

• • •

Legally the husband is the head of the house and the pedestrian has the right of way. Both are fairly safe unless they try to exercise their rights.

• • •

Two cannibals were in an asylum. One was tearing pictures of men, women and children out of a magazine and eating them.

"Tell me," said the other, "is that dehydrated stuff any good?"

The colonel was lecturing a class of ROTC students.

"A 40-foot flagpole has fallen down," he said. "You have a sergeant and a squad of men. How do you erect the flagpole again?"

The students thought, then made suggestions about block and tackle, derricks and so on.

"You're all wrong," said the colonel. "You'd say, 'Sergeant, get the flagpole up'."

• • •

The superintendent of an insane asylum noticed an inmate pushing a wheelbarrow upside down.

"Why do you have it upside down?" asked the superintendent.

"You don't think I'm crazy, do you?" was the reply. "I pushed it right side up yesterday and they kept filling it with sand."

• • •

A canny Scot was engaged in an argument with the conductor as to whether the fare was to be five or ten cents. Finally the disgusted conductor picked up the Scot's suitcase and tossed it off the train just as they were crossing a long bridge. It landed with a mighty splash.

"Hoot man," screamed the Scot, "first you try to rob me and now you've drowned my little boy!"

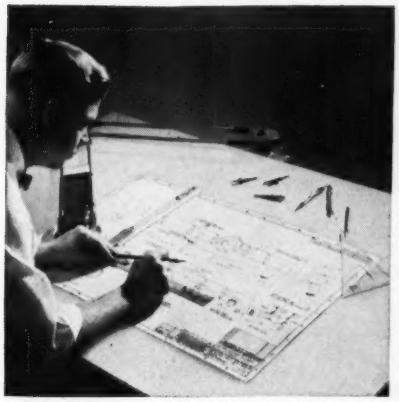
• • •

"You can't beat the system," moaned the student after his last semester's grades. "I decided to take basket weaving for a snap course, but two Navajos enrolled, raised the curve, and I flunked."

• • •

Two Indians had watched with much interest the building of a lighthouse off the rocky west coast. When it finally was completed they sat and watched it every night. A thick fog came rolling in one night and the siren blew continuously.

"Ugh," grunted one Indian to the other. "Light shine—bell ring—horn blow—but fog come just the same."



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One of a series*

Interview with General Electric's Charles F. Savage Consultant—Engineering Professional Relations

How Professional Societies Help Develop Young Engineers

Q. Mr. Savage, should young engineers join professional engineering societies?

A. By all means. Once engineers have graduated from college they are immediately "on the outside looking in," so to speak, of a new social circle to which they must earn their right to belong. Joining a professional or technical society represents a good entree.

Q. How do these societies help young engineers?

A. The members of these societies —mature, knowledgeable men— have an obligation to instruct those who follow after them. Engineers and scientists—as professional people—are custodians of a specialized body or fund of knowledge to which they have three definite responsibilities. The first is to *generate* new knowledge and add to this total fund. The second is to *utilize* this fund of knowledge in service to society. The third is to *teach* this knowledge to others, including young engineers.

Q. Specifically, what benefits accrue from belonging to these groups?

A. There are many. For the young engineer, affiliation serves the practical purpose of exposing his work to appraisal by other scientists and engineers. Most important, however, technical societies enable young engineers to learn of work crucial to their own. These organizations are a prime source of ideas — meeting colleagues and talking with them, reading reports, attending meetings and lectures. And, for the young engineer, recognition of his accomplishments by associates and organizations generally heads the list of his aspirations. He derives satisfaction from knowing that he has been identified in his field.

Q. What contribution is the young engineer expected to make as an active member of technical and professional societies?

A. First of all, he should become active in helping promote the objectives of a society by preparing and presenting timely, well-conceived technical papers. He should also become active in organizational administration. This is self-development at work, for such efforts can enhance the personal stature and reputation of the individual. And, I might add that professional development is a continuous process, starting prior to entering college and progressing beyond retirement. Professional aspirations may change but learning covers a person's entire life span. And, of course, there are dues to be paid. The amount is graduated in terms of professional stature gained and should always be considered as a personal investment in his future.

Q. How do you go about joining professional groups?

A. While still in school, join student chapters of societies right on campus. Once an engineer is out working in industry, he should contact local chapters of technical and professional societies, or find out about them from fellow engineers.

Q. Does General Electric encourage participation in technical and professional societies?

A. It certainly does. General Electric progress is built upon creative ideas and innovations. The Company goes to great lengths to establish a climate and incentive to yield these results. One way to get ideas is to encourage employees to join professional societies. Why? Because General Electric shares in recognition accorded any of its individual employees, as well as the common pool of knowledge that these engineers build up. It can't help but profit by encouraging such association, which sparks and stimulates contributions.

Right now, sizeable numbers of General Electric employees, at all levels in the Company, belong to engineering societies, hold responsible offices, serve on working committees and handle important assignments. Many are recognized for their outstanding contributions by honor and medal awards.

These general observations emphasize that General Electric does encourage participation. In indication of the importance of this view, the Company usually defrays a portion of the expense accrued by the men involved in supporting the activities of these various organizations. Remember, our goal is to see every man advance to the full limit of his capabilities. Encouraging him to join Professional Societies is one way to help him do so.

Mr. Savage has copies of the booklet "Your First 5 Years" published by the Engineers' Council for Professional Development which you may have for the asking. Simply write to Mr. C. F. Savage, Section 959-12, General Electric Co., Schenectady 5, N. Y.

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